Some Results from Managing the Process of Group Formation and Evaluation in Student Projects

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Abstract **The ISD – Information Systems Design course is in the core curriculum of most BSc/MSc engineering programmes of FEUP. In the programmes of Management and Industrial Engineering, Mechanical Engineering, and Informatics and Computing Engineering, the ISD course includes a group project. Students learn how to specify, design and build a prototype for an information system.**
In this work we aim to compare the impact of a new group formation method on the final grades of students. We compare results obtained when students were allowed to choose on their own the work groups with results when a Group Management Process (GMP) was used.
When using GMP students were asked to answer a standard questionnaire that attempts to classify typical behavior, and were assigned to groups by an algorithm that aims to achieve maximum diversity in a group together with homogeneity between groups.
GMP has the advantage of providing the students with additional soft skills, as they have to learn to work with less well-know colleagues. Contrarily to students' beliefs, this study concludes that there is strong evidence that when using GMP their final grades do not decrease, in general.

Index Terms – Group Assessment, Information Systems Design, Group Formation Process, Project Based Learning

INTRODUCTION

The undergraduate Information Systems Design (ISD) course is in the core curriculum of most of the engineering degrees of the Faculty of Engineering of the University of Porto (FEUP). Such first degrees are called "Licenciatura", run on a 15 week semester basis, excluding the final examination period, and require a minimum of five years full time of study or 300 ECTS (European credit units) to complete. Recently, such degrees were converted into BSc plus MSc equivalent degrees according to the Bologna Declaration.

In the Management and Industrial Engineering (LGEI), Mechanical Engineering (LEM) and Informatics and Computing Engineering (LEIC) degrees, ISD includes a group project. Students have to specify, design and build a prototype for an information system, and then present the results of their project. They use a very simple but effective user-centered software engineering project methodology, based on use cases and class diagrams from UML, and user interface mock-ups. Students usually choose the project theme on their own, and they can also involve real external users and customers. Before they go on to implement a prototype, using for instance MS Access and VB, they need to produce a requirements specification and initial draft design. The specification, the prototype and the final presentation are evaluated, and, as a result, an overall group project classification is given. Such grade accounts for half the final student mark.

In the past students of ISD courses were allowed to choose their own groups. We will call this method Free Group formation Process (FGP). Frequently, it results in a set of very unbalanced groups, with a few groups of very bright students and a few groups of not so bright students. In addition, many students keep working in the same group for several courses of their 5 year long engineering programme.

In the academic year of 2003/04, a Group Management Process (GMP) has been introduced, initially in the ISD courses of LEM and LGEI.

When using GMP, project groups are formed using a set of questionnaires that attempt to measure the students' type of behavior in a group (e.g.: *leader*, *strategist*, or *worker*). The results of such questionnaires are used to set up groups of students with some desired characteristics. In order to let the groups have some control over final classifications, each student should be able to evaluate his group colleagues, after the project was finished. Clearly there are some advantages of managing the group formation process. In such way students will have to learn to work with colleagues whom they are not likely to have worked with before. This will help develop some soft skills that will be important in the professional life, when they will have to work with colleagues, customers or other people they have not chosen. In fact, by forming groups composed of students having different profiles we aim to emulate a real working environment where teams are composed by workers with complementary skills. A group of students with a variety of profiles and not used to work together should promote the development of team work soft skills. In such environment each student's will have to develop his specific natural skills and learn to use them in the pursuit of a common goal.

Although it is difficult to compare the overall results the students have attained when using GMP with the results obtained when using FGP, statistical tests seem to show that the final grades do not decrease, in general. This result contradicts initial beliefs of students. As it was mentioned,

GMP has the advantage of providing the students additional soft skills. In addition, qualitative analysis (not provided here) seems to indicate that students have ended up understanding the benefits of the GMP approach. Feedback from employees of former alumni recommended that students should not be allowed always to work on their own groups (FGP).

THE INFORMATION SYSTEMS AND DATABASE DESIGN COURSE

Course objectives and summary program

The main objective of the ISD course is to prepare the students to design information systems that organizations need and that satisfy the users, considering the short, medium and long term. Although students from the LEM and LGEI degrees are not likely to be involved in the future in actual information system programming, they will nevertheless be involved in real teams from the user organization perspective, and therefore it is seen as crucial that such students acquire competences and practical knowledge in design and development. Such competences will make it easier for such students to participate in projects that aim at improving information systems, and therefore to have better information systems in organizations.

In order to achieve this overall objective the ISD course addresses the following five topics:

- Introduction to system analysis and design: determining system requirements [1], software process models, project management, contracting and procurement.
- Introduction to interaction design: designing the user interface, user-centred design, system usability and emotional factors [2].
- Simple UML based design process: introduction to the ER, OMT and UML modelling languages, modelling using use cases, classes, associations, aggregations and generalizations, deriving UML models from natural language problem descriptions [3].
- Relational database system concepts: overview of database systems, the relational model, introduction to the relational algebra and calculus, selection, projection, binary operators and joins, normalisation process, data redundancy and inconsistency, functional dependencies, normal forms, referential integrity, relational database management systems, query languages overview, introduction to SQL, selection conditions, functions, updating the database, joins and recursion, reducing class diagrams to tables [4].
- Introduction to business process re-engineering: critical success factor analysis, business processes modelling, and requirements engineering for information systems design [5].

Teaching and learning methods and evaluation

In practice, all students of three Engineering programmes have to attend each week a theoretical lecture that is not compulsory to attend, according to University rules. Such lectures aim at introducing the new concepts and information, and also presenting some problems and providing initial discussion. Given the large number of students, see Table 1, interaction is limited. Moreover, students have a formal tutorial class each week that they have to attend quite regularly. According to University rules they can fail the course if not attending such tutorial classes regularly. In LGEI, as there are only about 30 students, there is only one such class. In LEM and LEIC, as there are about 100 students, they are divided into 4 or 5 classes that meet separately. In total there are up to five lecturers providing support for students during the semester, for lectures, tutorials and out of class support.

Table 1 presents the number of groups that were formed for the three engineering programmes and for the three academic years of 2003/04 up to 2005/06.

TABLE 1
THE NUMBER OF STUDENTS AND GROUPS PER DEGREE AND PER YEAR.

	03/04		04/05		05/06	
Degree	Students	Groups	Students	Groups	Students	Groups
LEIC	80	20	91	21	106	28
LEM	94	24	103	25	112	26
LGEI	29	7	27	7	32	7

Roughly, the theoretical lectures follow the structure of presentation in the summary programme presented above. On this component, students will be evaluated with five short examinations during the semester, having to choose the four best grades. This evaluation component weights 20% in the final grade, and is also an incentive for students to study, and hopefully learn the subjects that are being introduced.

The tutorial classes start with an introduction to Access and Visual Basic (33% of tutorial classes), then go on into introducing and practicing with requirement specifications and simple UML class modelling (33% of tutorial classes), relational database design and SQL (33% of tutorial classes), and support for group project. All students have to pass a simple MS Access examination, with no weight for the final course grading. They will also be evaluated with two examinations, one covering class modelling and another one covering relational database design and SQL. These evaluation components weight 30% in the final grade.

All assessment components referred to so far are individual. Each student piece of work will be marked and an individual grade provided.

However the most important component of work by students is the group project that will be described in the following sections. Its overall weight in the final grade is 50%. It should be remarked that each evaluation component has some required minimum level of achievement required.

In the group project students can make use of all the knowledge they have on the course subjects. As it is well know, group projects have several advantages, coming both from group work, and from project work. For instance, as group work is concerned [6] mentions the following advantages:

- The development of a range of skills such as chairing, organisation, group/interpersonal work and peer tutoring.

- Ability to work in a team is one of the most important qualities looked for by most employers.
- Team work encourages creative thinking.
- Assessing group work saves assessment time.

The advantages of project work, either individual or in group, are well known, such as in PBL, Project Based Learning.

THE GROUP PROJECT

Each student will work in a small group of between 4 and 6 colleagues. Each group will have to propose a theme for the project. Lecturers have to accept the proposal as appropriate. Each project involves specifying, designing, building and testing a prototype for an information system, with an user interface and a relational database. Each group must submit an initial report with a specification of the system to be built, a proposed design for the database and user interface, and a project plan. After receiving feedback, the group will refine the design and start implementing the prototype. The whole process usually requires a lot of support from the lecturers, both on conceptual aspects and implementation detail. Finally each group has to hand in the prototype and has to make a final public presentation of the project, in the last tutorial class of the semester. The initial report, the prototype and the presentation are subject to evaluation by the lecturers. In the past there used to be a final report submitted and evaluated. This resulted from evolution of the initial one. Although the students are asked to keep an updated report, there is no requirement for its submission and no evaluation.

Therefore, final group project evaluation would depend on the initial report, the prototype and the final presentation. Individual assessment by the lecturers of each student's contribution to the group project is not considered viable. Although possible, individual assessment by lecturers regarding individual work in the group would be difficult to justify, as there are no individual deliverables. This lack of assessment always raised the problem of how to be fair to the individual members of the group and recognise their contributions.

Before 2003/04, this was the overall organization of the group project. From then on two innovations were introduced:

- Group formation was managed by a standard procedure, GMP, instead of letting students create their own groups, using FGP.
- A new evaluation component was introduced: each student in a group had to grade the colleagues, and this individual grade was considered in the final course grade.

The introduction of managed group formation will benefit if students are able to evaluate the performance of the colleagues in the group project. Previous attempts to introduce groups of students not using FGP, without some mechanisms for individual assessment, have raised some problems. There were several situations with students complaining that colleagues were not doing what was expected. It seems that when groups are setup by the students themselves, they have self-regulatory mechanisms in place, and there are not major problems in managing and distributing work. However, when groups are setup by a procedure, such informal control mechanisms can fail and group management will benefit from the possibility of cross evaluation.

STUDENT GROUP PROJECT FORMATION

Traditionally in the ISD course students would decide, on their own, which groups to set-up. In this process, that we called Free Group formation Process (FGP), lecturers would only require a minimum and maximum number of elements in each group, usually between 4 and 6 students. Although this process has some advantages, students get used to work with the same colleagues for as many years as they are at University and future employers often complain that new employees have some problems in working with different groups of people, in new projects. Additionally, some students claim that above average students tend to aggregate together in the same group.

Therefore it was decided to start a new process to set-up the groups that we called Group Management Process (GMP). Instead of setting up groups randomly, students were asked to answer a questionnaire to evaluate the most appropriate role of each student working in a group: the group role profile or just GRP [7]. Each student could be classified in one of the following eight profiles: a) president, b) strategist, c) intellectual, d) monitor/evaluator, e) operative, f) team worker, g) prospector, and h) finisher/retoucher.

When students set-up on their own the groups, they usually develop ways to compensate for team members that work less than average. However, if groups are set-up by the lecturers, either in a random or controlled way, it is necessary to provide the group with some way to distribute some sort of incentives or penalties internally. A previous experience where groups were formed by lecturers without any individual evaluation of the team members resulted in several internal conflicts. A few groups mentioned that members were not working well and there was nothing that could be done about it: no way to provide incentives or penalties to non–workers. Therefore it was decided that each group member would be able to evaluate their colleagues on a number of parameters and such evaluation would then be taken into consideration on the final mark of the group.

The process of group formation was oriented by the following objectives:

1. Each group should have between 4 and 6 elements (hard goal).
2. Each group should have students with different profile distribution, preferably one student of each type (soft goal). The eight original profiles were paired in order to reduce them to four profiles and make the grouping process easier to solve: i) president or strategist, ii) intellectual or monitor/evaluator, iii) operative or team worker, and iv) prospector or finisher/retoucher.
3. Every group should be similar in the distribution of student profiles (soft goal). This requirement aims to

guarantee that the global solution is adequate. For example, it is not acceptable to obtain a small proportion of groups with high diversity of profiles.

The students were informed of the way the process would be implemented and all their doubts and questions were answered. A great effort was taken to explain all the steps carefully. All the information that has been collected during the process, in particular the results of the GRP questionnaire were strictly confidential and lecturers who access to it had to conform to confidentiality agreement. Students were of course informed of such procedure.

A very simple algorithm was devised in order to set-up the groups automatically, while trying to satisfy the three objectives described above. The main idea of this algorithm is the following: if the profiles average for each group is close to the profiles average for the whole class, this means that the groups are homogeneous between each other.

The process is based on the random generation of a set of groups for each class. In order to evaluate each solution, each profile mean-square error is calculated relatively to the class average. A new solution that reduces the sum of these errors is chosen. This process is repeated until none (or very little) improvement is achieved [8].

STUDENT CROSS EVALUATION

As it has been stated, the final grade a student obtains at the end of the ISD course should include a component that results from cross evaluation in the end of the group project, by his group colleagues.

We wanted to make this cross evaluation process simple, usable, clear and efficient. The main requirements were that students had to evaluate colleagues on several different aspects of group work, not only technical performance aspects. The average of the grades given by a student to his group colleagues is fixed. Therefore, each student cannot give high marks to all colleagues, in all aspects. However he can provide all with the same overall classification. Finally, grades would be confidential, only lecturers having access to individual student grades. However, students would be informed of their overall average grade as given by his group colleagues.

In order to make the process simple and efficient once again a Web system was developed, based on the groups that were formed. Several alternatives were possible, and after initial research on the Web we decided to adapt the proposal [9], mentioned in [6]. Based on such proposal, a set of three criteria were used to allow each individual group member to evaluate each one of his colleagues:

- Regular attendance at group meetings and contribution of ideas for the task.
- Contribution to the cooperative group process, supporting and encouraging group members.
- Researching, analysing and preparing material for the task, and practical contribution to end product

An evaluation matrix should be completed by each student. This matrix is composed of three columns (one for each criterion above) and a number of rows corresponding to the number of group members minus one. Each student uses such matrix to evaluate his colleagues on each of the three criterion, using a 1 to 5 scale. The average of all the marks in each column must equal 3. This constraint avoids biases, such as very high marks or low marks for all students in the group.

It should be noticed that students were very positive concerning this cross evaluation process. Furthermore, they used this evaluation tool with enthusiasm and responsibility, rewarding or not rewarding the group colleagues. It is interesting to note that only in one of the groups all students have marked with 3 all the other colleagues.

This cross evaluation process in each group was not always applied in the three engineering programmes and in all the three academic years mentioned, due to problems of maintaining the web site. The impact of such cross evaluation will not therefore be subject to analysis here, but our experience shows that it is important to have it in place when applying GRP.

GROUP PROJECT AND INDIVIDUAL EXAM RESULTS ANALYSIS

In order to assess the impact of the GMP on the students' final results we conducted a statistical analysis on the grades obtained in three consecutive years. As shown previously in Table 1, the collected results refer to the 2003/04, 2004/05 and 2005/06 academic years, and to the LEIC, LEM and LGEI study programmes. Students of LEIC were allowed to choose their groups in 2003/04 and GMP was applied in 2004/05 and 2005/06. On LEM and LGEI, students choose their groups in 2004/05, and GMP was applied for the academic years of 2003/04 and 2005/06.

A student's final grade or mark is given in a 0-20 scale and it is the average of the group project grade and the individual examinations grade, each component having a 50% weight. Below 10, in the 0-20 scale, the student fails.

The next four figures show some results of the comparative study of grades obtained by students in the individual and the group components of their final marks in the ISD course.

Figure 1 shows the distribution of the group project grades and Figure 2 shows the distribution of individual exam grades, for the different programmes and academic years. These results show that, in general, students obtain higher grades in the group project than in the individual exam. It can also be seen that there are very few projects with grades below 10 (students' unacceptable performance or failure on the group project), but there is a considerable number of fail grades in examinations. We also notice, as expected, that there is a higher variability on the exams' grades than on the corresponding project grades.

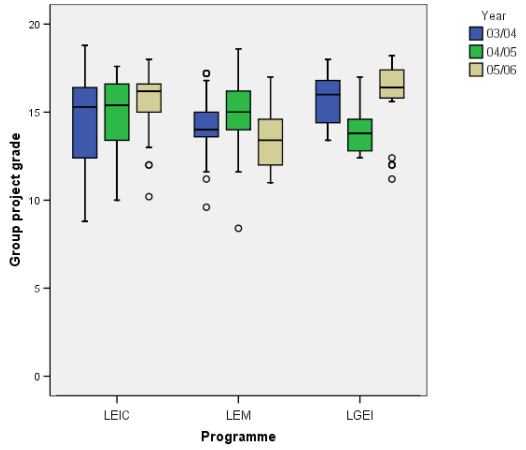

FIGURE 1
DISTRIBUTION OF GROUP PROJECT GRADES PER COURSE AND YEAR.

It is important to notice that the students of LEM and LGEI attended the same individual exams while the LEIC students had separate individual evaluations.

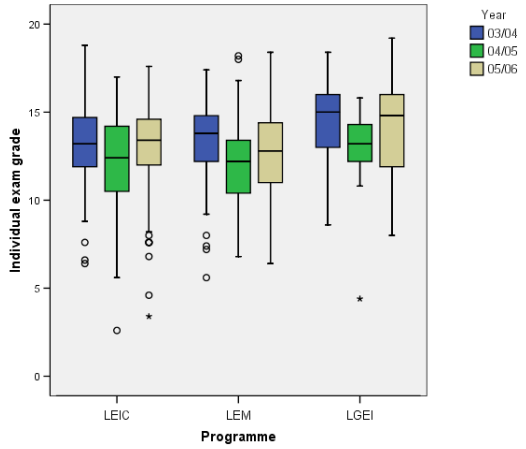

FIGURE 2
DISTRIBUTION OF EXAM GRADES PER COURSE AND YEAR.

We would like to stress that the introduction of GMP was aimed at helping students learn to work with colleagues with whom they are not likely to have worked before. The ability to work in a team involves soft skills reported to be very important by future employees. When evaluating GMP, we consider that the method is successful if the overall final grades do not get worst, since students learn important additional soft skills, as mentioned before.

Figure 3 shows the confidence intervals (95%) for the mean of the difference between each student's project grade and his individual exam grade.

When computing the difference between the group and individual grades we are considering that a student's exam grade is a measure of his overall individual academic ability. Thus, the difference between the group grade and the individual grade may highlight the impact of the group formation method on the overall individual final grade.

The results show, now even more clearly, that the group project grades are higher than the exam grades, since the differences are always positive. Statistical tests conducted show that, for each programme, the variance does not change among years. This means that the variability of the results is not significantly (95%) affected by the group formation method used.

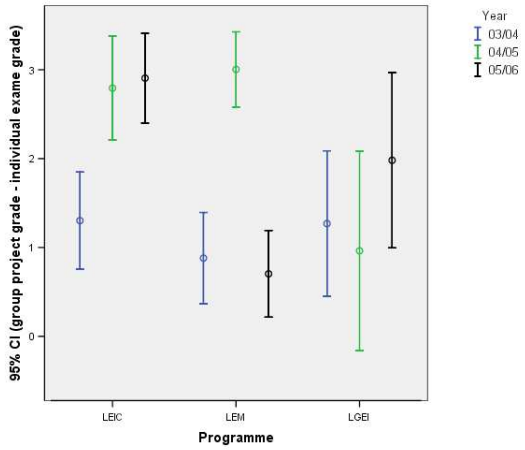

FIGURE 3
THE CONFIDENCE INTERVALS (CI) FOR THE AVERAGE DIFFERENCES BETWEEN GROUP PROJECT MARKS AND INDIVIDUAL EXAM MARKS.

In addition (not visible in the figures), the Analysis of Variance conducted on the data have shown that for LEIC the average grades improved significantly (95%) when GMP was used (2004/05 and 2005/06). However, for LEM, the grades were significantly (95%) better when the students were allowed to choose their groups (2004/05). For LGEI the group formation method used does not significantly affect the final grades. All these results need to be further studied, for example taking into consideration other individual grades the same students obtained in other courses, in the same academic years. Such grades may be a better reference for overall individual academic ability.

By applying GMP, we enable the students to develop additional skills and in approximately two thirds of the cases studied (number of students), the overall grades are not decreased, as feared by the students in the beginning. Therefore we could conclude from the analysis of these results that GMP should be used.

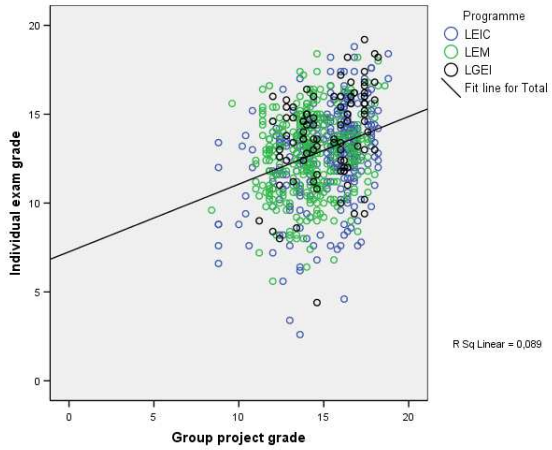

FIGURE 4
THE OVERALL VARIATION OF THE INDIVIDUAL EXAM MARKS AND THE CORRESPONDING GROUP PROJECT MARKS.

Finally, Figure 4 shows that there is a very low correlation (coefficient of determination of 0.089) between the group project grade and the individual exam grade, as we would expect. With FGP, we could expect some correlation (0.153), as bright students would like to be together in the same groups and not so bright students would also come together, as we can see in Figure 5. However, with GMP, we would expect much more homogenous groups, without strong correlation (0.068) between individual and group grades, as shown in Figure 6.

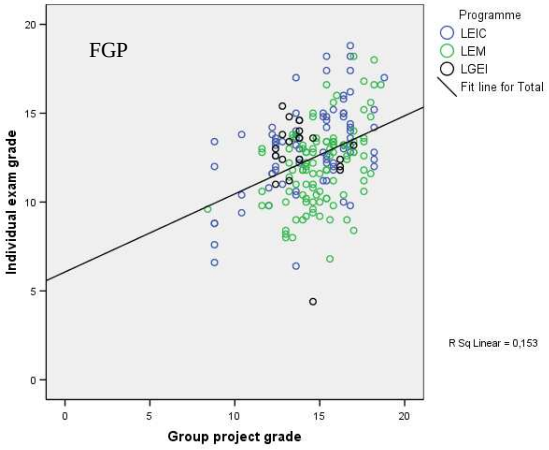

FIGURE 5
THE VARIATION OF THE INDIVIDUAL EXAM MARKS AND THE CORRESPONDING GROUP PROJECT MARKS FOR FGP.

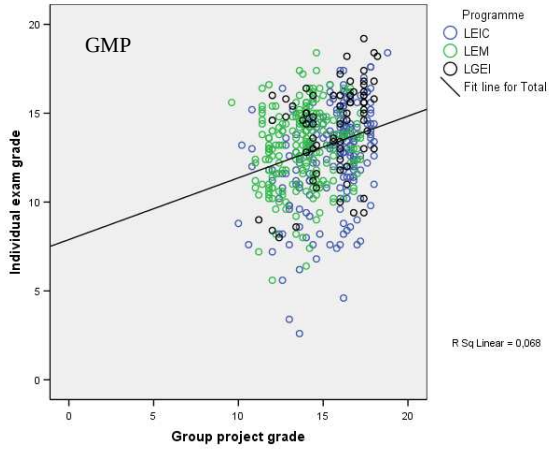

FIGURE 6
THE VARIATION OF THE INDIVIDUAL EXAM MARKS AND THE CORRESPONDING GROUP PROJECT MARKS FOR GMP.

CONCLUSIONS AND FURTHER WORK

In this work we presented a comparative analysis of two group formation methods on the final grades of students of the Information System Design course, in 3 study programmes in 3 academic years. Students of such courses have to conduct a group project whose goal is to design and implement an information system. The project groups are composed by 4 to 6 students.

It has been often referred to by employers the importance of preparing students with team work soft skills. Thus, we compare the results of a Free Group formation Process (FGP), in which students choose their own project groups, with the proposed Group Management Process (GMP), based on the answers to a questionnaire that try to evaluate students' personal skills while working in groups. A procedure was used in order to achieve maximum diversity in a group together with homogeneity between groups. GMP has the advantage of demanding from students additional skills. The comparative analysis of the students' grades revealed that, contrarily to their initial beliefs, the final grades do not necessarily decrease.

We plan to further explore the comparative analysis of students' grades when the two methods are used. In particular, we plan to take into account each student grades on the other courses completed in the year they attended the ISD course. We will have then an improved and more independent measure of the students' overall individual academic ability. In the current study such measure was taken by the same group of lecturers that was grading both individual and group ISD work.

In addition, we plan to further improve cross evaluation inside each group and measure in a more controlled way its impact in individual grades. Finally, we plan to improve the group formation algorithm, for example, by using metaheuristics techniques in order to find better and faster solutions.

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