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BUILDING CAPACITY IN REMOTE SENSING USING DISTANCE LEARNING

Formação em Sensoriamento Remoto Utilizando Ensino a Distância

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RESUMO

O objetivo deste artigo é apresentar a experiência do INPE na formação em sensoriamento remoto utilizando o ensino a distância. Nos últimos oito anos, a capacitação vem sendo conduzida por meio de cursos introdutórios cujo principal objetivo é difundir o uso de tecnologias de sensoriamento remoto, voltadas às aplicações ambientais. O TelEduc, ambiente computacional de código aberto e gratuito para ensino a distância, vem sendo utilizado como suporte para esses cursos, propiciando a interação entre alunos com diferentes formações. O material dos cursos inclui um livro texto, CD-ROM, vídeos e sessões interativas de web-conferência. Atividades práticas são conduzidas por meio de tutoriais e conjuntos de dados selecionados. Os alunos são incentivados a utilizar o sistema gratuito para Processamento de Informação Georeferenciadas – SPRING explorar dados de suas áreas de estudo, das fontes disponíveis (imagens CBERS e LANDSAT, mapas digitais e dados SRTM). O resultado destes cursos a distância tem sido gratificante. Os alunos têm demonstrado interesse crescente em realizar cursos mais avançados, o que incentivou o grupo de Educação a Distância (EaD) do INPE a implementar, em breve, esse tipo de curso.

Palavras chaves: Sensoriamento Remoto, Formação, Educação a Distância, TelEduc, CBERS, SIG (Sistemas de Informação Geográfica).

ABSTRACT

The objective of this paper is to present INPE experience in capacity building in Remote Sensing using e-learning. Over the last eight years, the capacity building has been carried out through introductory courses that main goal is to diffuse the use of remote sensing technology highlighting environmental applications. Teleduc, a free and open Learning Management System, has been used to support these courses fostering the interaction among students with different backgrounds. Course materials include text books, CD-ROMs, videos and web-conference sessions. Hands-on activities have been made available through specially well-organized tutorials and selected datasets. Students are encouraged to use SPRING (INPE image processing free software) and explore data from their own study areas among the several public sources available (CBERS and LANDSAT images, digital maps and SRTM data). The outcome of these online courses has been encouraging. Due to the continuous feedback from students showing their increasing interest for more advanced courses, the Distance Education Group at INPE intends to implement this kind of courses in the near future.

Keywords: Capacity Building, Remote Sensing, Distance Learning, TelEduc, CBERS, GIS (Geographic Information Systems).

1. Introduction

Remote sensing is a technology that acquires land surface data without instrumentally touching it. It is a very powerful tool in terms of information potential and instructional use by different school levels. The synoptic view and multi-temporality of remote sensing images are qualities that cannot be attained in traditional maps and other data sources.

Remote sensing images are valuable data source for environmental studies and monitoring. From Satellite images it is possible to get a wide variety of information that can be used in different subject areas (Agriculture, Geology, Geography, Biology, Architecture, Engineering, and Cartography), interdisciplinary studies and environmental education. Lately, there has been a rapid growth in the use of remote sensing technology in more diverse areas.

To ensure a skilled workforce to meet the demand of this expanding market for qualified professionals, it is essential for these Geospatial professionals to have a solid education. Within the process of converting remote sensing data into accurate information, these professionals shall be able to correctly infer about the information and make the right decisions (JENSEN, 2001).

Unfortunately not many teachers and other professionals have gotten to know about this technology. Few undergraduate courses have a remote sensing required discipline in their curriculum, but recently this has begun to change. With the increasing interest in the use of remote sensing in other fields, the instructional demand on its use has also increased. The expanded availability of data and software over the Internet, with free access, as well as, the increasing number of different applications using remote sensing, is also contributing to this growing demand for more and better training courses on remote sensing. Furthermore, the number of training courses available that covers this subject is still small. In Brazil distance learning has become a crucial tool for broadening education outreach to its territory and making available quality programs and materials to different audiences. In this context, distance education courses were created at INPE.

INPE's concern with education dates back to 1968 when the SACI Project (Advanced System of Interdisciplinary Communication) was created: a technological system of communication for distance learning. The objective of this initiative was to test the effectiveness of programs for primary schools, transmitted via satellite (radio and TV) to schools, with active participation of teachers at the schools. It involved teachers' capacity building, as well as, development of educational material and formative and summative assessment in the classroom. (BICUDO, 1976). An ambitions pilot project was implemented in Natal (Northeast of Brazil), where, for some months, attended hundreds of public school students, helping to eradicate illiteracy in this poor region of the country. Unfortunately, due to political reasons out of the scope of this paper, this project was soon extinguished for lacking infrastructure and qualified human resources.

Remote Sensing education started in 1972 as one of the INPE´s missions in the Earth Observation Coordination (OBT) when a Master's Degree program was created. More recently, in 1998, a Doctoral program was also established. Since then,

many other educational activities related to remote sensing and GIS have been conducted either in São José dos Campos (where INPE headquarters is located) or in other institutions in Brazil and abroad, upon demand.

In 1985, INPE created an international course on remote sensing at the specialization level. In the beginning, it was a seven-month course and primarily dedicated to professionals from Latin America, the Caribbean and Africa. From 1993 onwards, the course was designed exclusively to professionals from Latin American and Caribbean countries. So far, more than 215 professionals from Latin America and Africa have received a specialization certificate in remote sensing. Regarding South America, there were 53 students from Brazil, 24 from Peru, 22 from Venezuela, 20 from Colombia and 15 from Argentina (SAUSEN, 2003).

In July of 1998, the Remote Sensing Division (DSR/OBT) offered the first forty-hour course for elementary and high school in-service teachers from both public and private schools entitled "The school use of remote sensing for environmental studies". Since then, INPE has been offering this course every year and it has been successful in spreading the use of remote sensing as an educational tool among teachers. The teachers are encouraged to develop a project in their school with their students using remote sensing data to look at and study a local environmental problem.

Since 1999, the Image Processing Division (DPI/OBT), in partnership with SELPER-Brazil (Society of Latin-American Specialists in Remote Sensing), has offered traditional (in-house) short-term courses aimed at supporting the use of geotechnology in Brazil. The students come from various backgrounds and application interest areas such as Geology, Geography, Engineering and Cartography. Most of them work at institutions or companies that need an application of remote sensing at some level (FERREIRA *et al*., 2002).

The demand for courses has been increasing over the past years and INPE has not been able to match it. There is a limit in the number of instructors available for teaching as well as suited facilities. Additionally, students usually have limited financial resources that preclude them from traveling, since many of the students live in cities faraway from INPE´s headquarters. Therefore, most of them have to pay not only for the course but also for accommodation, food, and local transport.

Considering this scenario briefly described and the need to provide means of accessing information, the authors of this article formed a group at INPE with the task of redesigning the educational outreach program and defining new methods that could effectively replace traditional classroom learning environments. With the strong belief that e-learning (a combination of education and Internet using different web technologies) is the answer for attending INPE´s demand for effective instruction and material delivery, this group decided to implement distance education courses (FERREIRA *et al*., 2005).

A first attempt to incorporate new technologies into INPE´s Remote Sensing Graduate Course was carried out in 2002, when TelEduc (Learning Management System developed by researchers the State University of Campinas - UNICAMP (Rocha, 2002) was introduced to support face-to-face classes, in a blended learning style.

Since 2004, more than twenty e-learning remote sensing training courses have been carried out at INPE using the TelEduc environment. There are several advantages in using this approach to education, such as flexibility of time, independence of geographic location and distance, more cost-effective meaning than person-to-person training, and the adoption of a learner-centered approach where learners control their learning pace and development.

According to Bhuasiri et al. (2012), online learning systems provide benefits for stakeholders located around the world. Advantages of e-learning for learners include an increased accessibility to information, better content delivery, personalized instruction, content standardization, accountability, on-demand availability, self-pacing, interactivity , confidence, and increased convenience.

As reported by Moran (2011), distance education has changed the way of teaching and learning, even in the face-to-face and blended courses, making use of tools for rich collaboration among participants, such as, chat, discussion forums, web-conferences, portfolio etc.

In the study carried out by Bhuasiri et al. (2012), there were found six dimensions for implementing e-learning systems in developing

countries, including learners´ characteristics, instructors´ characteristics, institution and system quality, infrastructure and system quality, course and information quality, and extrinsic motivation. Conforming to these authors, the most important dimensions for e-learning system are the learners and instructors characteristics.

The efficiency of distance education must involve constant interaction among teachers and students, students and e-learning environment, and among students themselves. One of the main challenges that our group (and most other groups) faces today is to reach a high quality standard on e-learning courses.

According to Valente (2011), in most e-learning courses, the emphasis lies on transmitting information instead of an active construction of knowledge. In this sense, these Geotechnology courses carried out at INPE have been focusing on lessons that build new concepts from previous knowledge, in familiar and meaningful context for the students. Furthermore, the courses have been engaging students in activities that promote real social interaction (being together virtually, VALENTE, 2002).

This capacity building program started with the undergraduate teachers because they are multipliers and they have easier access to computer laboratories. The first e-learning course created in May, 2004 ("The Use of Remote Sensing for Environmental Studies for Undergraduate Professors") aimed at disseminating remote sensing as part of the curriculum and pedagogical resource to teaching science topics in universities. The main idea was to create collaborative learning opportunities for college educators fostering their continuing professional development, reinforcing the importance of applying new technologies, and encouraging them to spread what they have learned among students and colleagues. Along 2005 and 2006, three more courses were offered, always including suggestions and improvements based on student feedbacks.

In 2005, in order to match the increasing demand (not only by undergraduate professors but also by technicians and researchers from environmental institutions around the country), the group at INPE decided to offer an introductory course ("Introduction to Remote Sensing"), reaching a broader audience.

More recently, in 2009, a specific course was created ("Geotechnologies at School") toward filling the needs of elementary and high school teachers interested in developing multidisciplinary projects with their students in the classroom.

In this context, the objective of this paper is to present INPE experience in capacity building in Remote Sensing using e-learning. Thereby, the materials used and the methodologies applied are presented and the results obtained are discussed.

2. MATERIALS AND METHODOLOGY

2.1 Materials

The remote sensing training courses have been carried out using TelEduc environment. From this Learning Management System, the following subset of tools is used: Course Dynamic, Agenda, Evaluations, Activities, Support Material, Readings, Exercises and Frequently Asked Questions. The tools Discussion Forums, Chat, Mail and Portfolio have been explored for interaction among instructors and students.

A combined image processing and GIS freeware package called SPRING (www.dpi.inpe.br/spring) with Portuguese, Spanish, English and French versions, was also used. This software is a state-of-the-art GIS and remote sensing image processing system with an object-oriented data model, which provides for the integration of raster and vector data.

The courses included selected instructional materials such as a text book, CD-ROMs and videos. The book entitled *Iniciação em Sensoriamento Remoto* (Florenzano, 2011) is one of the main sources for introducing Remote Sensing information. This book provides information on satellites and sensors, image interpretation, remote sensing applications for environmental studies and shows a large potential for classroom activities. The interactive educational CD-ROM entitled *Aplicações para a Preservação, Conservação e Desenvolvimento Sustentável da Amazônia* (Dias *et al*., 2009) provided, is divided in three sections (1) introduction to preservation and conservation, (2) introduction to remote sensing principles and satellite image processing, and (3) Amazon case studies based on LBA-Ecology research. This CD includes high quality graphics, animations, audio, video, interactive exercises and

quizzes. Many aspects of this CD-ROM are based on an existing set of CDs developed by Indiana State University under an NASA GRANT (MAUSEL *et al.,* 2001).

For more interactivity, Web-conference sessions have been held as support to the classes. Hands-on activities have been made available through specially well-organized tutorials and selected datasets. Specially well-organized tutorials for guiding students on digital image processing techniques including procedures for image registration, enhancement, segmentation, and classification (Mello *et al.*, 2005) were prepared and made available to students. At each course edition, this material is revised and updated, based on the new SPRING releases.

These tutorials include selected examples of satellite images over the Brazilian territory. Applying the Learner-Centered Principle, students are often encouraged to explore images of their interest areas.

2.2Methodology

In 2004, the first e-learning course (a pilot experience) was implemented during three weeks, including four instructors and fourteen students. The following three courses ran for seven weeks and had 30 selected students each. The number of instructors increased from four to seven. Undergraduate faculty with different backgrounds (Engineering – Civil, Agronomic, Agriculture, Environmental and Fishing, Geography, Biology, Architecture, Chemistry, Physics, Cartography and Geology) was selected.

These first four courses were structured based on a required students´ involvement of twelve hours per week, distributed between mandatory classes, activities, and complementary and optional readings, as well as weekly chats with instructors. The activities included the development of a project proposal that should incorporate an environmental theme addressed by a remote sensing technique.

Students are always encouraged to gather data for their own study areas among the several public sources available (CBERS and LANDSAT images, digital maps, SRTM data etc.) and to use the software SPRING for processing these data.

The CBERS program, a joint effort between Brazil and China, has brought significant scientific advances to Brazil, being its images used for deforestation and fire control in the Amazon region and for monitoring of water resources, agricultural activities, urban growth and land cover change. These data are critical for large-scale strategic projects, like PRODES (Program for Deforestation Assessment in the Brazilian Legal Amazonia), and for monitoring and managing landscape occupation associated with environmental projects (INPE, 2011).

The nine classes (three per week) covered the following topics: 1) how to use TelEduc and prepare a thematic or educational project proposal, 2) basic environmental concepts, 3) remote sensing principles, 4) image Interpretation, 5) image processing, 6) examples of remote sensing applications, 7) online advisory on the proposal preparation, and 8) final assessment and course evaluation.

From 2006-onwards, besides the eight topics described above, the content of the courses emphasized digital image processing, and were remodeled to only one classes per week during the three-month period. The increased duration of these courses, as well as the extended chat sessions in two periods (morning and afternoon) were implemented due to student suggestions received during the evaluation of the first courses.

Based on the concept of being together virtually, several small adjustments were made during the courses, such as: adding three more instructors, providing extra chat sessions (some in the evening), and exploring others tools available in the TelEduc environment (Bulletin Board and Discussion Forums).

In 2011, aiming at exploring new ways of improving and encouraging student participation with synchronous strategies, web-conference sessions, using RNP (Brazilian National Education and Research Network), were introduced. The online sessions using were recorded, saved in a file, and made available to students. It captured all screen activity during the online session, interaction and audio.

In the last two years, the Discussion Forum Tool has been introduced seeking to simulate the social networks principle. According to Valente (2011), social networks such as Twitter, YouTube and Flickr can and must be used in the classrooms as pedagogical tools. Instructors, from a variety of backgrounds including Cartography, Computer Science, Geography and Remote Sensing, closely

monitored and supervised, at all times, the discussions inside the Forum.

The instructors, students, instructional materials and software (TelEduc and SPRING) were evaluated at the end of every course, by students, who were also asked to make a self-assessment of their performance during the course.

From the fourth course on, besides undergraduate teachers, the students included technicians and researchers from Brazilian public institutions such as INPA (National Institute of Amazonian Research), EMBRAPA (Brazilian Enterprise of Agriculture and Livestock Research) and IBAMA (Brazilian Institute for Environment and Natural Renewable Resources). They often use remote sensing technology applied to environmental studies and many times with an educational focus. Since 2009 an edition course was also created for in-service elementary teacher training. In this kind of course the content is the same but reduced and simplified and its objective is to motivate the use of the Geotechnologies as a didactic resource in the classroom.

Since the beginning, student selection criteria included geographic location as one of the most important. Students living far from INPE headquarters had preference, because they have more difficulty in attending courses at INPE and, also, have less access to information.

3. RESULTS AND DISCUSSION

A compilation of all 22 courses offered from 2004 to 2012 is shown in Table 1.

According to the literature, the average dropout of distance education courses is around 25 to 40% (LEVY, 2007). This percentage was observed for the courses Use_SR (first four) and GEO_School (last four). In the GEO_School courses, the percentage of students that successfully completed the courses drops to around 50% (44% in 2009, 40% in 2010, 38% in 2011 and 55% in 2012). The performance in the last course gets slightly better, but still very low. Some elementary and high school teachers, especially the ones graduated a longer time, encounter difficulties with e-learning courses because of their lack in computer skills. Besides, most of them have little background in image processing techniques and have difficulty learning such complex and unfriendly packages (e.g. SPRING) in a couple of weeks. Unfortunately not all schools have the adequate infrastructure or support from the principals (FLORENZANO *et al.*, 2011).

In spite of these limitations, the results obtained with these GEO_School courses are considered qualitatively very good. The students that overcame the initial difficulties and concluded the course were successful when applying the Remote Sensing techniques with their own students in the classroom. Afterwards, the evaluations sent reflected their highly motivation for using new technologies in their practices.

The better results obtained in the Intro_SR courses can be explained by the background of participants who were mostly technicians, having pressing needs to apply Geotechnologies and Remote Sensing in their daily work. Moreover, they probably have more time to dedicate to the courses when compared to undergraduate professors who are more involved with students, projects and research in general.

During the Image Processing Module, students learn the techniques for Image enhancement, Image Registration, Image Fusion and Image Segmentation and Classification, using the SPRING software. Up to 2010, during this module, students followed by themselves, the steps from the tutorials, and were asked to report their achievements inside the Bulletin Board. The support from teachers was basically done through the Mail and Bulletin Board tools, being the interaction basically among teachers and students.

The better results obtained on the last two Intro_SR editions are likely due to the introduction of activities in Groups and the use of the Discussion Forums tool (still not implemented in Geo_School courses), which allowed more collaboration and interaction among students when following the step-by-step tutorials. It is worth mentioning that the instructors come from a variety of backgrounds (Physics, Computer Science, Cartography and Geography) and experiences, making this exchange of information even richer.

The use of web-conferences has enabled all participants of the Intro_SR courses (2011 and 2012), to share audio, video, text, images, and their computer screens, including the manipulation of the SPRING program in real time. Considering the difficulty of gathering all the students on time for classes online, it was fundamental to have these

Table 1 – Number of students that applied (candidates), were selected and enrolled, and successfully completed each course.

COURSE	CANDIDATES	SELECTED	ENROLLED	CONCLUSION	% Successfully Completed the Course
1 - Use_SR (May/2004)	61	18	14	11	79%
2 - Use_SR (Aug /2004)	96	35	22	14	64%
3 - Use_SR (Feb/2005)	65	30	24	18	75%
4 - Use_SR (Feb/2006)	129	42	26	20	77%
5 - Intro_SR (May/2005)	180	53	36	33	92%
6 - Intro_SR (Sep/2005)	140	40	27	18	67%
7 - Intro_SR (May/2006)	233	54	30	22	73%
8 - Intro_SR (Aug/2006)	77	52	34	27	79%
9 - Intro_SR (Mar/2007)	524	84	50	37	74%
10 - Intro_SR (Sep/2007)	169	68	37	32	86%
11 - Intro_SR (Apr/2008)	259	90	41	33	80%
12 - Intro_SR (Sep/2008)	146	82	56	41	73%
13 - Intro_SR (Apr/2009)	265	48	37	25	68%
14 - Intro_SR (Setp2009)	155	74	39	25	64%
15 - Intro_SR (Mar/2010)	267	86	47	34	72%
16 - Intro_SR (Sep/2010)	313	89	60	47	78%
17 - Intro_SR (Aug/ 2011)	575	91	52	45	87%
18- Intro_SR - (Apr/2012)	127	79	44	36	82%
19- Geo_School (Sep/2009)	291	58	18	8	44%
20- Geo_School (Mar/2010)	70	57	25	10	40%
21- Geo_School (Aug/2011)	86	69	39	15	38%
22- Geo_School (Feb/ 2012)	32	28	20	11	55%
TOTAL	4260	1327	778	562	72%

Use_SR: The Use of Remote Sensing for Environmental Studies for Undergraduate Professors
Intro_SR: Introduction to Remote Sensing
Geo_School: Geotechnologies at School

classes recorded, saved and made available for further consultation by students at any time of their convenience. It is important to notice that all the material available on TelEduc environment can be accessed even after the end of the course.

Table 2 shows the diversity of students´ backgrounds from Intro_SR courses. It can be noticed that most participants had Engineering and Geography backgrounds. Notice that Engineering includes Agricultural, Agronomic, Environmental, Cartographic, Civil, Forest, Geological, Chemical and Mechanical).

Figure 1 depicts the widespread participation of students from all regions of Brazil with different backgrounds, including Latin America and Other Countries (USA, Canada, Spain, Portugal, Germany, Netherlands, Angola, Mozambique and France).

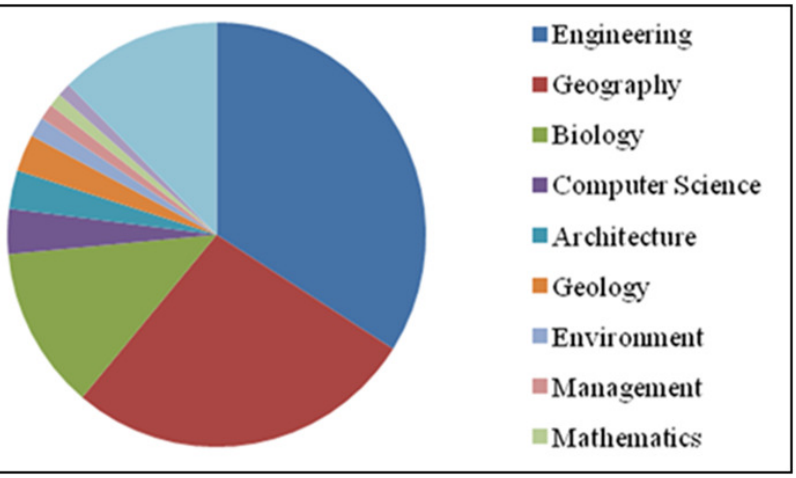
The Chat has proved to be a very useful tool for providing synchronous interaction among participants. Besides time flexibility, it allows recording the sessions for later access. Students not able to participate can read the records afterwards and solve their own doubts.

Both Formative (providing feedback during learning) and Summative (measuring learning at the end of the process) Assessments have been performed for all courses. Assessing performance and monitoring student progress was done using the TelEduc tools Portfolio and Discussion Forums. In the image classification activity, for instance, the students need to perform a series of tasks predefined by a set of specific steps. If they do not perform satisfactorily they will not obtain the designed outcome. It is very difficult to cheat on obtaining these results.

The courses are designed in a way that the instructors attentively follow the students, understanding their ideas and elaborating a well-qualified feedback, which are both necessary for

Table 2 – Backgrounds of selected students from Intro_SR courses.

Background	
Engineering	337
Geography	268
Biology	123
Computer Science	34
Architecture	29
Geology	28
Environment	15
Management	12
Mathematics	10
Military	10
Others	124
TOTAL	990



the construction of knowledge of both teachers and students. In this scenario, instructors are able to assist students and monitor their progress firsthand immediately responding to any doubts they might have, challenging them and encouraging their participation in the group, ("being together virtually").

Overall, course contents and instructors received excellent evaluations from most students in all Intro_SR courses (Figure 2 and 3).

TelEduc proved to be a robust and reliable distance education managing system. It has satisfactorily performed the important role of supporting course development and monitoring course performance during implementation. All students evaluated this system as being efficient and friendly (Figure 4).

Despite of the traditional difficulty in acquiring complex knowledge, such as remote sensing techniques and applications, most students had good performance in the tasks proposed and were able to learn the concepts, principles and processes associated with this technology. The results were even more satisfactory considering the wide range of topics covered, the lack of background by most students and the diversity of the student population, which usually affects the learning that takes place in distance education courses.

4. CONCLUSIONS

The outcome of these courses has been encouraging showing that learning about image interpretation and processing is feasible through e-learning.

Face-to-face training courses or even blended learning can be more efficient, but the geographic outreach of the distance learning is

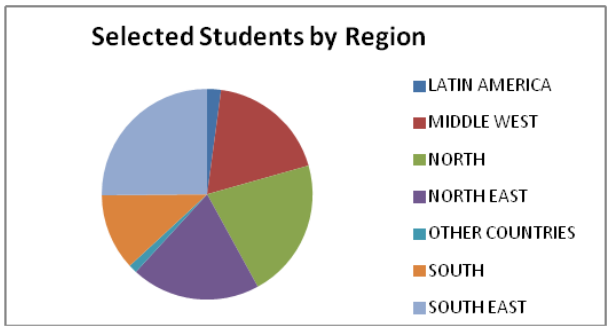


Fig. 1 – Selected students by region from Intro_SR courses.

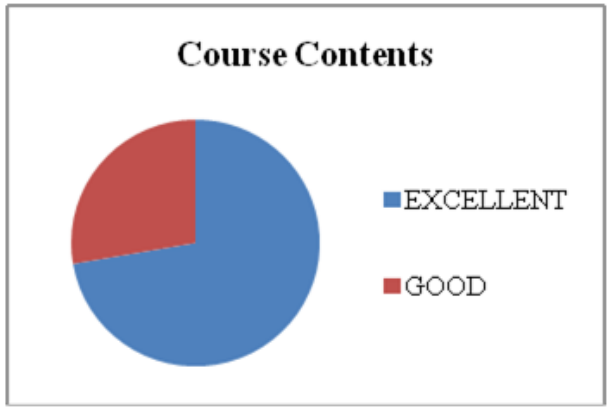


Fig. 2 - Evaluation from students about Courses Contents (Intro_SR courses).

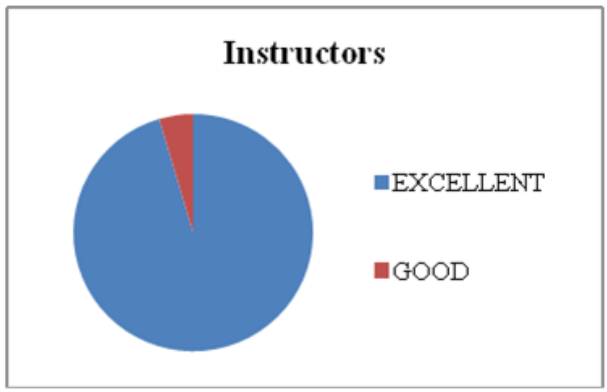


Fig. 3 - Evaluation from students about Instructors Performances (Intro_SR courses).

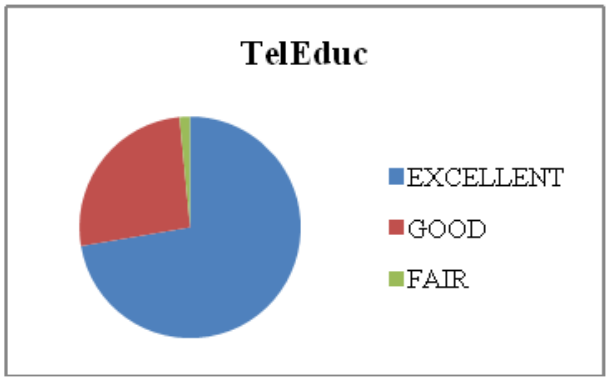


Fig. 4 - Evaluation from students about TelEduc (Intro_SR courses).

incomparable when one considers a country of large territorial extension such as Brazil, with such limited resources.

We attribute the success of teaching such complex topics by e-learning to the tools used, the quality of the materials provided to students, the support given to students by each instructor ("being together virtually") and, of course, the exceptional dedication to learning demonstrated by most students. High quality material is important not only for students learning but also for the dissemination of remote sensing by the students in their own classrooms, institutions and communities.

The main characteristic of these courses is that there is a lot of student-teacher and student-student interaction, which was made possible by the way students learn in an effective e-learning environment. The teachers are able to assist the students in their progress and immediately respond to their learning needs. Even for image processing activities, the results show that personal tutoring can be satisfactorily fulfilled with e-learning.

Additional improvements such as tutorial updates, exploration of additional tools (web-conference, forums and group activities) and evaluation strategies were important in order to optimize the last courses performance and student learning. However, there is still room to explore new resources and methodologies, since e-learning, as a field, is still young and rapidly evolving

In respect to the elementary and high school teachers, the results showed the need to promote not only improvements in the in-service teacher training courses but also in the pre-service teacher training. On INPE´s side, to achieve better results in this Geo_School courses, the group intends to explore new resources and improving teaching-learning methods.

The experience gained during the courses offered and increasing demand have encouraged this group to pursue the development of new courses focusing on more advanced topics.

It is important to highlight that the quality of these courses is highly dependable on the commitment of the current group of instructors.

The proposal of new advanced courses will depend on the expansion of this group, including specialists with other expertise.

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