

CREATION OF AN INTERNATIONAL ENGINEERING STUDENT EXCHANGE PROGRAM

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Abstract

This paper describes, from the perspective of two U.S. universities, the creation of an international engineering student exchange program, involving universities in Canada, the United States, and Mexico. The program was funded by the Department of Education in the United States, and by the equivalent government agencies in Canada and Mexico. The program provided travel subsidies for engineering students to travel to study engineering at a partner university in another country, either by taking classes or by doing a research internship. The theme for the program was energy efficiency.

This paper describes the process used to put the program together and to administer it. Experiences, both good and bad, and lessons learned are presented.

Introduction

In early 2010, a consortium of two Canadian universities, two U.S. universities, and two Mexican universities submitted a joint proposal to establish a four-year long engineering student exchange program entitled the “Alliance to Promote Sustainability of the Environment Through Energy Efficiency Across NAFTA.” The program had five objectives. The primary objective of the program was to train engineering students, through courses and internship experiences, in the most modern techniques for achieving energy efficiency in buildings, plants and automobiles, thus promoting the sustainability of the environment. Another objective was to encourage student and faculty mobility, thus encouraging the free exchange of ideas between engineering students and faculty from the participating universities. In a similar manner, one objective of the program was that participating students and faculty should gain an increased appreciation of countries and cultures besides their own. Another objective was to develop undergraduate course

materials in energy efficiency that could be shared between partner institutions, in order to improve courses and degree programs offered at each school. Finally, an important objective of the program was to establish lasting relationships between the partner institutions that would continue well beyond the end of the formal program.

The Alliance to Promote Sustainability of the Environment Through Energy Efficiency Across NAFTA is now in its final year of implementation. This paper describes the method used to put the consortium together, to propose the program, and to implement it. The accomplishments of the program are reported and discussed. Certain conclusions are presented, as well as recommendations for future consortia of this type.

Background

Student exchange programs for engineering are not new, of course. Many other researchers have investigated best practices for such programs. A few examples of previous work include the efforts of Kelly et al. [1], and Crown et al. [2]. This project has attempted to build upon those successes.

Method

Putting Together the Consortium

The Université de Moncton took the overall lead for establishing the consortium. The Université de Moncton had previously been involved in ten funded North American and four funded European mobility programs that involved approximately thirty universities in ten countries. They had already been very successful with the approval and coordination of mobility projects involving the Business School, and they built upon the success of those projects to propose an engineering-oriented project.

The Université de Moncton and the Universidad Panamericana had previously been engaged in a highly successful cooperative relationship on several North American mobility projects since 2000. The Alliance was built on this relationship and the accomplishments of the previous programs. The University of Louisiana and Université de Moncton have had an ongoing bilateral agreement since 2009, and were engaged in a highly successful cooperative relationship. In addition, the Cajun cultural influence at University of Louisiana at Lafayette provides a unique connection to the Acadian cultural influence at Université de Moncton. Thus, the Universidad Panamericana was chosen as the lead institution in Mexico and the University of Louisiana at Lafayette was picked to be the lead university in the United States.

The lead institution in each country was then responsible to find a partnering institution in their own country with which they had worked, and with which they had a close relationship. The Université de Moncton chose Ryerson University to participate in the

program, because they had already worked together on a Canada-European Union Program for Co-operation in Higher Education, Training and Youth in 2009 in the field of technology. The University of Louisiana at Lafayette chose Lamar University as its U.S. partner because the two universities have strong cultural and technical ties, plus faculty members at the two universities had already collaborated on various research projects and established personal relationships. The Universidad Panamericana chose to partner with the Universidad Autónoma de San Luis Potosí because of strong ties due to ongoing collaboration on many projects. Thus, the consortium was established to consist of the Université de Moncton and Ryerson University in Canada, the University of Louisiana at Lafayette and Lamar University in the United States, and the Universidad Panamericana and the Universidad Autónoma de San Luis Potosí in Mexico.

Proposing the Program

The Université de Moncton also took the overall lead for writing the proposal. Major sections of the proposal included a narrative section to explain the rationale for the proposed program, a description of the partner institutions, a work plan that included deliverable products for each year of the program, a budget section, and a section to identify participating personnel at each institution and their qualifications. In addition, the U.S. proposal needed to include a plan for external assessment.

In early 2010, the consortium submitted a joint proposal to establish an engineering student exchange program entitled, the “Alliance to Promote Sustainability of the Environment Through Energy Efficiency Across NAFTA.” Each lead university submitted the proposal to the appropriate funding agency in their country. In the United States, the funding agency was the U.S. Department of Education, under the Office of Postsecondary Education, and the Fund for the Improvement of Secondary Education (FIPSE), Program for North American Mobility in Higher Education. In Canada and Mexico, the grant was funded by similar agencies in their own governments. The grant was awarded in the summer of 2010, and the first meetings of the consortium took place in October of 2010 in Minneapolis, Minnesota, in the United States. The meeting was co-hosted by the administrators of the U.S. Program for North American Mobility in Higher Education and their counterparts from Canada and Mexico. At that meeting the administrators of the mobility programs from each country explained how the program would be managed, and the various consortia members held break-out meetings to make plans to begin implementing their programs. The first meeting turned out to be crucial for establishing a good working relationship between all the team members.

Implementation

This section will describe the crucial efforts involved in the implementation of the project.

Memorandum of Understanding

The first task undertaken by the consortium was to establish a Memorandum of Understanding (MOU) between all the partner institutions. This document had to be provided to the three governments during the first year of the project and the document was required before the partners could start exchanging students and had to be approved by the six participating universities.

The first part of the MOU included the purpose and overall goals of the project, as well as definitions of important terms, such as “sending institution,” “term,” and “exchange student.” A section was also included to identify the lead institutions in each country and the manner in which any issues would be resolved. The largest single section of the MOU was entitled “Student Exchange,” and it covered the following topics: 1) consortium responsibilities, 2) sending institution responsibilities, and 3) receiving institution responsibilities.

It was decided that it would be the responsibility of each consortium member university to enroll students received under the agreement as full-time students for the duration of their visit, in accordance with their own admission and enrollment policies, and to grant to them the same rights as other students at their university. Member universities were indemnified against any injury or loss sustained by visiting students.

Sending institutions had the responsibility to recruit candidate exchange students and to help them to apply to the receiving institution of their choice, but the receiving institution retained the right to admit the student or not based on their own admissions policies. This became especially important in some cases with regard to the student’s proficiency in the language of the receiving institution. Sending institutions were required to coordinate with the receiving institution prior to the arrival of the student, in order to provide any necessary transcripts, test scores, or other academic records, to prepare the student culturally, to prepare the student with regard to any special insurance requirements at the receiving institution, and to pay to the student the allotted stipend provided by their government to help defray their expenses.

Receiving institutions had the responsibility to prepare and provide the necessary documentation to allow the exchange student to apply for the necessary student visa to enter the country and to become a student at the receiving institution. Of course, the receiving institution was not required to guarantee that the government of their country would actually issue the necessary visa. The contact person at the receiving institution would insure that the application information of the exchange student would be routed through the appropriate channels at their institution to receive an admission decision, and were required to provide a reason for non-admission if that should be the case. Receiving institutions were to provide to incoming exchange students information about housing, meal plans, and other important information. Receiving institutions were to treat the exchange students as if they were their own students, and to provide them ID cards and

ordinary student access to library services, computing services, and other student facilities. Exchange students were to follow the same discipline and intellectual property policies and procedures as other students at the receiving institution. If necessary, receiving institutions retained the right to terminate the visit of the exchange student in accordance with their normal discipline procedures. At the end of the exchange, the receiving institution would provide a transcript and other evaluation documentation as appropriate (for internships, for example) and forward those documents to the sending institution.

Another important section of the MOU had to do with student fees and financial support. Under the MOU for this program, exchange students paid their normal tuition and fees as a full-time student to their home university, and they were not charged the equivalent tuition and fees at the receiving university. Fees that had no equivalent at the sending institution must be paid by the exchange student at the receiving institution, however, so an important aspect of any successful MOU is a detailed comparison of fees that are charged at the various institutions, so that all parties will be clear on which fees will be waived and which will not. Any costs associated with housing, meals, supplemental insurance (if necessary) or other miscellaneous expenses were to be paid by the exchange student. The sending institution was to provide each exchange student with a stipend to help defray their expenses. The amount of the stipend varied according to the rules of the funding agency in each country. In the United States, the stipend was \$5,000 (U.S.) per semester.

The MOU stated that it was the goal of the program to achieve the transferability of credits between the various institutions to the greatest extent possible, given the laws and accreditation rules of the participating countries. A formal articulation agreement was not made part of the MOU, but one of the first tasks of the consortium after the signing of the MOU was to establish a table of equivalent courses between the six universities. Because this consortium was organized around the topic of energy efficiency, equivalent courses in the Mechanical Engineering curricula of each university were identified and it was agreed that these courses would be accepted as transfer credits under the MOU. The transferability of other courses was addressed on a case-by-case basis as the need arose.

Other important sections that were included in the MOU were details regarding the recruiting of students, internships, faculty collaboration, and intellectual property rights, and designated contact persons for each university. The MOU was signed by the president or rector of each participating university within three months of the beginning of the project, setting the stage for rapid movement to the next stage in the project, which was to begin recruiting students.

Recruiting and Selecting Students

In order to inform and attract students, a website was created to provide general information about the program and each participating university [4]. A table of

equivalent courses and a list of contact persons was also provided on the website. A simple one-page downloadable application form was provided that allowed interested students to indicate their interest in the program to the contact person at their home university, who would then begin the selection process used at their institution.

Each university established its own recruiting and selection procedure. Methods for recruitment of students included e-mail notices to students, which directed them to the website, printed posters, and in-class announcements by faculty. Also, as participating faculty visited the various universities, they were typically given a chance to meet with students at that university and to make a pitch inviting students to come to their university under the program. In the United States, a faculty member from the lead institution traveled to the partner institutions to help advertise the program.

A typical procedure for selecting students was to review the applications received and invite the interested students in for personalized interviews in which their suitability for the program was assessed, based on academic preparation and maturity, knowledge of the applicable foreign language, and cultural preparation. The interests of the students in terms of where they would like to go and what they would like to do (take classes or perform an internship) were also considered. An effort was made in the selection of students to achieve a balance of student exchanges between the institutions such that each university sent and received nearly the same amount of students.

Sending and Receiving Students

The first exchange students began to travel in the latter half of the first year of the program. Once a student was selected by the home institution, the brief application form completed by the student was forwarded to the prospective receiving university for review and comment. If an initial review of the brief application form was positive, then the contact persons from the sending and receiving universities began working together to help the student to complete the necessary application forms for the receiving institution, and to forward the appropriate transcripts and academic records for the student. The contact persons also helped to co-advise the student regarding the proper courses to take. In the case of an internship, the contact persons would work together to identify and arrange for an appropriate internship opportunity for the student. Once the application materials from the student had been received and approved, the receiving institution sent the student a letter of acceptance that the student could use to obtain a student visa.

As the date of travel approached, the contact persons from the sending and receiving institutions worked together to help find the student appropriate housing and register for classes or make contact with their internship mentor. When the student arrived, he or she was typically greeted by the institutional contact person, who would assist the student in navigating the university procedures for obtaining a student ID, getting moved into student housing, finding their classes, and in identifying other local resources, such as grocery stores, and cultural attractions. Throughout the semester the contact person

stayed in touch with the visiting students to insure that they were succeeding with their classes or internship and to help with any problems that might arise.

Assessment and Reporting

At the end of each visit, the receiving university would send evaluation documents to the sending institution, such as transcripts and internship evaluations. In addition, the faculty contact person at the receiving university was typically asked by the sending institution to submit an evaluation form for each student indicating the extent to which they had fulfilled the terms of the sending institution. Questions on the evaluation forms were typically of the type: Was their attendance record satisfactory? Did they perform well in their classes or internship? Did they obey all local laws and the rules of the receiving institution? Did they take part in cultural activities? Did their foreign language skills increase? The sending institution sometimes required a positive evaluation from the receiving institution in order to pay a portion of the student's stipend.

Students who were sponsored by the United States and who traveled to either Canada or Mexico were required to write a report upon their return describing their experience. They were also required to participate in a survey prior to the release of the final portion of their stipend.

The United States required an external evaluator to write a yearly evaluation of the progress of the U.S. institutions participating in the program. At the end of each year, the lead institution submitted an annual report to the funding agency, and also to the external evaluator. The evaluator was also provided copies of the student reports, and on the basis of the annual report and the student reports, the evaluator assessed the yearly progress of the program. The report of the external evaluator was also filed with the funding agency.

Results

This section will present the results of the program in terms of the five objectives: 1) student training in energy efficiency, 2) student and faculty mobility, 3) increased appreciation of different cultures, 4) development of educational materials in the area of energy efficiency, and 5) the establishment of continuing relationships between partner institutions that will continue after the end of the formal program.

Student Training and Student Mobility

Student training and student mobility will be considered together, since the number of students trained is the same as the number of students who traveled. The number of students who participated began small and grew as students returned and began to spread by word of mouth the benefits of the program. There is one semester left on the program

and it is expected that several more students will travel. To date, student mobility can be summarized as shown in Table 1 below:

From/To	Moncton	Ryerson	Louisiana	Lamar	UP	UASLP	Total
Moncton			13	3		1	13
Ryerson			3				3
Louisiana	2	1			1	1	5
Lamar							0
UP		1	3				4
UASLP	2	4	8	1			15
Total	4	6	27	4	1	2	44

Table 1 – Student Mobility Matrix

Faculty Mobility

Table 2 below indicates the number of faculty who traveled under this program to visit other schools to participate in seminars, give lectures, recruit students, attend planning meetings, and participate in cultural activities.

From/To	Moncton	Ryerson	Louisiana	Lamar	UP	UASLP	Total
Moncton			4	1	2	2	9
Ryerson			2	1	2	1	6
Louisiana	1	1		2	1	1	6
Lamar	1	1	2		1		5
UP	2	2	3	2		1	10
UASLP	2	3	2	2	1		10
Total	6	7	13	8	7	5	46

Table 2 – Faculty Mobility Matrix

From a faculty perspective, it can be reported that the visits to the various participating universities proved in every case to be an extremely valuable experience. By visiting the partner universities, the faculty were able to gain a deeper understanding of the quality of the programs offered, the quality of the students at the other universities, the types of energy-related challenges that face the various countries, and the unique solutions that have been employed to solve those challenges. In addition, the visits allowed the faculty to observe the environment and culture at each university, in order to better advise interested students regarding the best university to visit in order to meet their own educational goals.

In addition, because some students expressed certain fears with regard to visiting other universities, the visits of the faculty to each participating university allowed the faculty to

observe the situation first-hand and report factual information to the students. For example, some students initially expressed concern that they might be caught in a hurricane if they visited Louisiana, caught in a blizzard if they visited Canada, or caught in a drug-related shootout if they visited Mexico. By actually visiting the partner institutions, the faculty were able to allay the unrealistic fears of potential exchange students. Another benefit of visiting the various partner universities was the ability of the faculty to deepen their personal relationships with their peers in their sister institutions. The importance of knowing that there is a friend on the faculty at a partner institution who will be sure to take personal care of one's students when they visit cannot be overstated.

Increased Cultural Appreciation

It is difficult to assign a numerical value to the increase in appreciation for different languages, cultures, and countries as a result of this program, but the comments on every student evaluation have been positive. Every student who participated in the program reported an improved appreciation for the language, culture, and country of the university which they visited. Every student surveyed reported that they would recommend this program to their friends, and that they would repeat an experience like this if they had the opportunity.

Development of Educational Materials Relating to Energy Efficiency

To date, the consortium has created three lesson modules, which are able to be shared among partner institutions. These modules are on the topics of heat recovery in industrial furnaces, heat recovery on a university campus, and solar thermal energy. Several additional energy efficiency-related modules will be completed before the end of the project. These lesson modules will be available to the public on the consortium website even after the conclusion of the project.

Two international symposia on energy efficiency have been conducted, one at the Universidad Panamericana and one at the University of Louisiana at Lafayette. Both students and faculty participated in these symposia. Over 150 people participated in the symposia. The presentations from these symposia are also available on the consortium website.

One student presented the results of his energy efficiency research internship at a conference sponsored by the U.S. Department of Energy. His presentation is available at the conference website [3]. The present paper will also be published in the proceedings of ASEE Gulf-Southwest Conference [4]. A journal paper is also planned.

Establishment of Continuing Relationships

At the most recent and final consortium meeting, plans were made to establish on-going bi-lateral agreements between the participating universities. All parties expressed a desire to enter into such agreements and draft agreements were created and circulated for comment. It is expected that by the end of the project on-going bi-lateral agreements will be in place for all parties in the current consortium. The hope is that undergraduate students will continue to travel abroad to consortium schools even after the current funding expires, and that graduates from partner universities will attend other universities within the consortium for graduate studies. In addition, it is hoped that the relationships developed as a result of this experience will result in other joint research proposals being submitted by partner schools.

Discussion of Results

This section will discuss the results presented above. The overall original goal for this program was to have 42 students travel under this program. As can be seen from Table 1, that goal has already been exceeded with one semester left for student travel. The secondary goal of having each institution send and receive approximately the same number of students was not achieved. The distribution was uneven. All schools did receive exchange students under this program. The school chosen most often was the University of Louisiana at Lafayette, with almost four times the number of visiting students of any other school. This may have been due to the energy related research internships offered at that school. The Université de Moncton and the Universidad Autónoma de San Luis Potosí were by far the most successful in recruiting students to travel abroad. The other schools were less successful. So far, none of the Lamar students have chosen to travel abroad. In order to identify the issues that have discouraged Lamar University students from traveling, a survey was conducted. The results of that survey are shown in Appendix A. In summary, however, the main reasons that Lamar students were reluctant to travel were a lack of foreign language skills and a fear that the stipend was too small to cover their expenses. These results will be used to try to recruit students from Lamar to travel during the final semester, which will be the summer of 2014.

Table 2 shows that the exchange of faculty members was much more evenly distributed. Representatives from each school visited each other school as part of this program. This was a matter of deliberate planning, whereas the number of students who traveled to each school was partly a matter of choice, attraction, and selection on the part of the students. The faculty visits proved to be a crucial part of the overall success of the program.

In all cases there was an increase of cultural awareness on the part of the participants, although the increase was difficult to quantify. The fact that all participants indicated that they had a positive experience indicates that the program was successful.

The program has produced a significant amount of educational material on the subject of energy efficiency that are now available to the public, so it would appear that the program was successful on this front.

Because all partners have indicated a willingness to continue the program through bi-lateral agreements after the current funding expires is another indication of the success of the program.

Lessons Learned and Recommendations

Positive Experiences

On the positive side, it was discovered that research internships conducted by participating faculty turned out to be a very popular option. It was also discovered that students who had returned from abroad were the best advertisement for the program.

Difficulties Encountered

Initially, one of the most challenging aspects of the program, at least in the United States, was that while engineering faculty make excellent advisors and mentors for the visiting students, they do not necessarily make the best points of contact for helping students submit admissions documents, obtain visas, insurance, housing, and so on. It was not until the engineering faculty partnered more closely with the International Student Office, the Admissions Office, and the Housing Office that the procedure began to operate smoothly.

Another issue encountered was that occasionally, the course that a student from one institution needed to stay on track with their curriculum was not offered by the receiving school in the semester of the visit.

Recommendations

Recommendations for future collaborations of this type would begin by making sure that the consortium is made up of universities that either already have strong ties or are compatible in terms of size, academic culture, and mission. Another key factor, of course, is that both the administration and the faculty must be supportive and have strong buy-in to the program. Active and frequent communication between the representatives of each university is essential for a successful program. Faculty visits to participating schools are crucial for the formation of the personal ties that will enable the program to continue after the funding has expired. Another recommendation would be to have a representative from the International Student Office as a co-PI on the project for each school, in order to bring their expertise to the table.

Summary and Conclusions

In conclusion, the Alliance to Promote Sustainability of the Environment Through Energy Efficiency Across NAFTA has proven to be a successful engineering-oriented student exchange program to date. Four of the original five objectives have already been achieved or exceeded, namely: 1) student training in energy efficiency, 2) student and faculty mobility, 3) increased appreciation of different cultures, 4) development of educational materials in the area of energy efficiency. The fifth objective of the establishment of continuing relationships between partner institutions is expected to be complete before the end of the formal program.

References

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- [4] Consortium Website for the Alliance to Promote Sustainability of the Environment Through Energy Efficiency Across NAFTA, available at: <http://engineering.louisiana.edu/Exchange%20Webpage/>

Appendix A – Survey Results

The ASEEAN Project is also known as the **Alliance to Promote the Sustainability of the Environment through Energy Efficiency across NAFTA**. It is a federally-funded program to enable engineering students, especially mechanical engineering students, from the partner universities to go abroad and experience another culture and language at one of the consortia campuses and communities. The partner universities are two in Canada, two in the US¹, and two² in Mexico. This experience can be done in the form of taking classes for credit or working with a professor in his/her research lab. Lamar will provide a \$5,000 stipend to help cover expenses for the semester. You would be responsible for anything over that amount.

Last week you saw a PowerPoint presentation about the program by Dr. Terry Chambers, Associate Dean, College of Engineering, University of Louisiana, Lafayette. He invited you to consider participating in the program. While there was a certain level of interest expressed. This survey is meant to gauge that level of interest.

The consortium is drafting a paper discussing the multi-year project. One of the points to be discussed is why more students didn't participate. At the recent consortia meeting on the Universidad Panamericana campus in Guadalajara, Mexico I volunteered to do this survey to identify reasons for the non-participation of Lamar's students.

Please indicate all factors that described your view of the exchange program. Your input to the quality of the forthcoming paper will be appreciated.

What factors did you like about the program? – Num. of Responses (out of 35)

- I would get experience abroad. - 28
- I would experience another language and culture. - 20
- I could take classes for credit that would transfer back to Lamar. - 27
- I could get research lab experience working under a professor. - 21
- I would get a significant stipend to help cover expenses. - 18
- Other positive benefit of participation in the program: - 3

What factors did you NOT like about the program? – Num. of Responses (35)

- It would delay my expected graduation date. - 14
- It would cost too much. - 18
- I don't see the value for me in participating in the program. - 4
- I could not get all the courses on the host campus that I need. - 0
- I don't want to learn (or improve) another language. - 7
- I was concerned about my safety / security in the host community. - 8

¹ US students must go out of country.

² But involve three campuses

- I have never been abroad in a situation similar to this. - 6
- Other negative aspect of participating in the program: - 16

If the program were continued, what do you suggest be changed to make the experience more attractive to students? Why? (representative responses shown below)

- 1) **Try to get more schools involved, so that we can have more options.**
- 2) **Make it more accessible to English-speaking students. Perhaps an intro class to Spanish/French? I would want to do the program, but the campuses that appealed to me most were all non-English speaking and Toronto is the most expensive.**
- 3) **There is really nothing that should be changed. I think students are already attracted to the experience; however, I am simply not interested.**
- 4) **Maybe have more details of research that you would be doing while there. More pictures of the campuses or surrounding area.**

Present average cost of living in the area.
- 5) **Europe, especially U.K. Easier for a student to assimilate, instead of Mexico.**
- 6) **Give us more money, \$5,000 isn't enough.**
- 7) **Possibly have someone who has completed the exchange program and has been hired by a company explain the benefits of the program and how it helps in the work force.**

Appendix B – Partial Course Equivalency Matrix

Université de Moncton	Ryerson University	University of Louisiana - Lafayette	Lamar University	Universidad Autónoma de San Luis Potosí	Universidad Panamericana
<p>GMEC 3411 – Thermodynamic Introductory comments. Concepts and definitions. Pure substances' properties. Work and heat. The first principle of thermodynamics. The second principle of thermodynamics. Entropy. Irreversibility and availability. Power cycle and refrigeration cycle.</p>	<p>MEC 309 Basic Thermodynamics Introductory concepts and definitions: Thermodynamic systems, fluid properties. Energy, work, heat. First law. Cycles. Properties of a pure, simple compressible substance: substances that appear in different phases, ideal gas model. Control volume analysis: conservation of mass and energy. Second law: irreversible and reversible processes, Carnot cycle. Entropy: Clausius inequality, entropy change, entropy balance for closed and open systems, isentropic processes and efficiencies. Gas power systems; Air Standard Otto, Diesel, Dual and Brayton cycles. Engine testing.</p>	<p>ENGR 301. Thermodynamics. (3, 0, 3). Study of the laws of thermodynamics, available energy, mixtures, thermodynamic properties of matter, and applications to engineering systems. Prereq: CHEM 107, MATH 270.</p>	<p>2374 Thermodynamics I The properties of a pure substance and equations of state: The first law and second law of thermodynamics and their application in analysis of thermal process. Basic concepts of thermodynamic cycles and thermal efficiency</p>	<p>Clave : 5618 Termodinámica Conceptos básicos y sistemas de unidades, conceptos de energía, primera ley de la termodinámica, segunda ley de la termodinámica, gas ideal y la sustancia pura, procesos termodinámicos, ciclos termodinámicos.</p>	<p>ETF002 Termodinámica. Análisis termodinámicos básicos a máquinas térmicas e hidráulicas y en general de dispositivos empleados en la industria, aplicando los conceptos, principios y leyes de la termodinámica.</p>