AC 2007-301: TRAINING INTERNATIONALLY RESPONSIBLE ENGINEERS

Allyson Frankman, Brigham Young University
Allyson Frankman is a PhD Candidate in Chemical Engineering at Brigham Young University (BYU). She is one of the co-founders of the Engineers Without Borders Student Chapter at BYU.

Jacob Jones, Brigham Young University
Jacob Jones is a Senior in Chemical Engineering at Brigham Young University (BYU). He is one of the co-founders of the Engineers Without Borders Student Chapter at BYU.

W. Vincent Wilding, Brigham Young University
W. Vincent Wilding is a Professor of Chemical Engineering at Brigham Young University. His research interests include thermophysical properties, phase equilibria, and environmental engineering. He received his B.S. degree in Chemical Engineering from Brigham Young University in 1981 and his Ph.D. in Chemical Engineering from Rice University in 1985.

Randy Lewis, Brigham Young University
Randy S. Lewis is Professor of Chemical Engineering at Brigham Young University and an Adjunct Professor of Chemical Engineering at Oklahoma State University. He received his BS and PhD degrees in Chemical Engineering from Brigham Young University and Massachusetts Institute of Technology, respectively. His research interests include biomaterials development and the utilization of renewable resources for the production of chemicals.

Training Internationally Responsible Engineers

Introduction

With engineering increasingly becoming an international discipline, engineering training will require students to understand and work with different cultures, peoples, practices, ethics and paradigms. Organizations such as Engineers for a Sustainable World (ESW) and Engineers without Borders (EWB) are just two organizations that are bringing sustainable development issues into the classrooms through the formation of chapters at universities. Krishna S. Athreya, director of ESW, explains that the goal of ESW is to "educate a generation of engineers to have greater understanding of global issues and the ways technology can be employed for human progress" and in turn, Athreya explains, "helping the impoverished have a better life can, for students, be a life-changing experience."[1]

A recent article discussed how undergraduate engineering students were involved in engineering projects to help solve the problems of the developing world. Projects ranged from simple (e.g. creating a tool for removing kernels from dried corn) to complex (e.g. design an inexpensive cytometer for hospitals). In the development of the tool for removing kernels, students stated "… we found in the class that it's not always the technical aspects that are important—it's also cultural."[2]

Opportunities for engineering graduates to apply their expertise to solve both technical and social problems in the world around them will be beneficial to them in future careers. An article in the Cornell Chronicle observed, "No longer the 'me generation', American engineering students are actively taking on some of the world's toughest problems…students and professional engineers [are] working to improve the lot of some of the world's poorest communities, many in the developing world."[3] Helping the impoverished have a better life enables students to look beyond themselves into the world around them.

In order to engage engineering students from many disciplines in a global opportunity, a new variable credit (1-3) course was developed and is currently in progress during the Winter 2007 semester. For all engineering disciplines (chemical, civil/environmental, electrical/computer, and mechanical), the course is applicable towards one of the student's technical elective requirements. Students from all engineering and technology disciplines were invited to enroll, thus enriching the class with different strengths, viewpoints and backgrounds. The course was open to those who completed or were concurrently enrolled in the pre-requisites for their professional program. The course revolves around designing and implementing an engineering solution to a local issue in an impoverished community.

This year's project involves the developmental plan and small-scale implementation of biodiesel production from coconut oil on the Pacific Island of Tonga. 50 years ago, Tonga's economy centered around the export of coconuts and coconut oil. In the 1980's soybeans came onto the world market, and the price for coconut oil dropped dramatically, forcing all coconut processing facilities in Tonga to go out of business. Losing their primary export drastically hurt the Tongan economy, and it has never fully recovered. Tonga currently generates *all* their electricity using diesel generators. Unfortunately they have to import the diesel, and at $4.20 a gallon, their energy prices relative to their wages are one of the highest in the world.

The project involves converting under-used coconuts (and other oils) into the highly valued resource of biodiesel. Biodiesel burns cleaner than regular diesel and has no net-greenhouse gas emissions. The biodiesel that is generated can then be used in all of the same ways as normal diesel. This not only can help poor Tongan farmers have a way to sell their coconuts, but it will keep the money that Tongans are spending on energy in Tonga. The biodiesel that is produced can also be used to power the pumps that provide clean drinking to the Tongan villages. Currently these villages can go up to a week without clean water because they cannot afford to buy the diesel fuel to power the pumps.

The project involves three aspects: 1) Engineering students developing a comprehensive plan for incorporating biodiesel production in Tonga using coconut oil- including implementation of a small-scale biodiesel facility, 2) Professors and students from the course visiting Tonga to present the biodiesel plan to the Prime Minister and local coconut farmers and to identify areas in which engineers can become involved in future engineering projects, and 3) Professors developing an internship program while in Tonga for future undergraduate students to apply engineering solutions and to provide technical assistance to the people of Tonga.

Course Structure

The course is titled "Global Projects in Engineering and Technology" and offers the opportunity for engineers to work on a global problem, researching not only technical but economical and socio-cultural issues. Students have the opportunity to work on teams with engineers from at least two other disciplines. From this team experience, students are learning that boundaries between engineering disciplines fade and all engineers at the simplest levels are problem solvers, each contributing a unique viewpoint or technical background to innovatively solve the problem at hand.

The course competencies are:

- Students will exhibit innovative problem solving skills as they apply their engineering training to global engineering projects in developing countries.
- Students will demonstrate effective oral and written communication skills in the reporting of work.
- Students will demonstrate effective teamwork and leadership skills and an appreciation for other disciplines as they work together on interdisciplinary teams.
- Students will develop an understanding of and appreciation for global aspects of engineering.

Application to the class was through a written essay as enrollment was initially limited to 30 students. Because the project focused on biodiesel production, the ratio of chemical engineers that applied was high compared to other engineering disciplines. However, a good mix of engineering disciplines enrolled in the course: 12 chemical engineers, 7 mechanical engineers, 5 civil engineers, 4 electrical engineers and 2 computer engineers. In addition, one biology student with a technical background was accepted to the course. The makeup of the class is primarily juniors and seniors although there are a few sophomores and two graduate students.

The first half of the semester focuses on technical aspects of the project, while the second half of the semester focuses on implementation and social impacts of the project. The course includes a number of expert guest lectures throughout the semester presenting different aspects of creating sustainable engineering projects: project management and teamwork, technical overview of the project, and bridging cultural gaps. In addition, students are required to choose a book to read from a reading list of ~30 international development books to motivate students to think about issues of integrating projects in a global environment.

The class is divided into different teams (6 teams with 4-6 people per team). The teams were chosen based on student preference (first or second choice) and were arranged so that there was a good mixture of majors (at least 3 majors per team) and experience (sophomore-graduate student). Each team is responsible for a different segment of the project and must work co-currently with the rest of the teams in designing the entire project. Class members assume team roles such as leader, data collector, liaison with other teams etc, and are ultimately responsible for their aspect of the project, research and report writing. However, volunteers from the EWB Chapter are invited to assist in the research and/or problem solving. Each team is assigned a mentor (a faculty member, graduate student or volunteer working professional). This mentor has the responsibility to encourage students to search out all aspects of their particular assignment, provide a sounding board for ideas and offer technical advice and guidance. In addition, teams are required to submit write ups and/or presentations to their mentors and fellow classmates to ensure that the class is not back-loaded with the majority of the work getting done the last few weeks of the semester.

The distribution of points for the various credits is shown in Table 1 below. The guaranteed grade distribution is: 93.5-100% (A), 90-93.5% (A-), 87-90% (B+), 83.5-87% (B), 80-83.5% (B-), 77-80% (C+), 73.5-77% (C), 70-73.5% (C-), 60-70% (D), <60% (F).

Students are held accountable for their work and are evaluated on their individual and team performance. Because the course is offered as a variable (1-3) credit class, students are required to keep a log of hours they spend working on the project. The class requires 2 hours per week outside of class for each credit hour the student is registered. From a student's log of hours, students are given two points for every hour spent up to a maximum of 60, 120, and 180 points for the 1, 2, and 3 credits, respectively. Other individual assignments include a 15-minute cultural presentation on one aspect of Tongan culture (government, arts, geography, history, community structure and economics etc.) and a 2-minute devotional at the beginning of each class from one student giving a thought about the importance of humanitarian work and/or service to others. The final consists of a 5-minute presentation from each student on some aspect of the Tonga trip itinerary.

Table 1. Distribution of Points for Various Assignments and Credits

	1 Credit	2 Credit	3 Credit
Team Assignments			
Project Plans (2 @ 10 points each)	20	20	20
Written Memos (4 @ 10 points each)	40	40	40
Progress Reports (2 @ 15 points each)	30	30	30
Technical Report (including operation manual)	100	100	100
Final Report	100	100	100
Technical & Final Presentations (2 @ 50 points each)	100	100	100
EWB & Liahona Poster	50	50	50
Breadth experiences (3 @ 20 points each)	60	60	60
Total Group	**500**	**500**	**500**
Additional points (up to 25 points) may be earned on an individual basis for exceptional efforts on the team assignments. The additional points will be based on team and mentor assessments completed at the end of the semester.			
Individual Assignments			
Readings & 2 page write up	N/A	40	40
Team Participation	60	120	180
Devotional	5	5	5
Cultural Presentation	N/A	N/A	40
Research Journal & Log	25	25	25
Final	10	10	10
Total Individual	**100**	**200**	**300**
Team Participation: Points will be based on 2 point per each hour spent on the ***project*** *outside of class. Hours must be documented in the Research Log.*			
Total Class Points	**600**	**700**	**800**

Team Structure

The six teams and their associated tasks are:

- Oil Extraction Team – develop an efficient method for collecting, cracking, drying, and extracting the oil from the coconuts
- Biodiesel Reactor Team – develop a procedure for converting the coconut oil into the correct purity of biodiesel using an off-the-shelf biodiesel reactor which traditionally uses vegetable oil as a reactant
- Separations Team – develop a method to obtain a sufficiently pure biodiesel product (including engine testing) for use in a diesel engine,
- Reactor Waste Team – research potential uses for other products from the reactor (such as glycerol) and how to dispose of waste water in an environmentally friendly manner

- Value Added Team – provide additional ways to add value to the project, including other ways to use the excess coconut parts (husks, shells, milk, etc.) and to research additional oils that may be used to make biodiesel (jatropha, palm, soybean, etc.)
- Economics Team – investigate the factors which will control the viability and profitability of the process (especially in the Tongan culture) including finding a market for the biodiesel, storage and transportation, etc.

There are a variety of team assignments, including two project plans (a detailed plan of team structure, key goals and deadlines), one due at the beginning of the technical section and one due at the beginning of the social implementation session. Required written memos help students maintain good communication with their mentor and consist of four parts: a) current progress, b) key questions to still answer, c) road blocks to be addressed, and d) pertinent issues or limits that affect other teams. Two technical reports are required, a technical report (including an operation manual) that covers all the technical aspects of the project and a final report, which covers both the technical and the social implementation aspects of the project.

In order to give students oral presentation experience, students are required to give a technical presentation mid-way through the semester and then a final presentation during the last week of the semester. In addition, two poster sessions will be held, one presented at the monthly EWB meeting and one at the Liahona High School in Tonga.

To help students see the broad view of the project and not just the details of their individual assignments, breadth experiences are also introduced. In these experiences, every team is required to have hands-on experience in all three technical processes using the student-written technical operating manuals: the oil extraction, the bioreactor and the separations processes. This experience will help provide feedback on how to improve the operating manuals.

Visit to Tonga

Following the Winter 2007 semester (which ends in late April), members of the class (on a voluntary basis) will travel to Tonga with mentors for a period of two weeks. Students will provide their own travel funds supplemented with money from on-campus development organizations and the college/department matching funds. Students will have the opportunity to observe and participate in the rich Tongan culture in addition to the following deliverables:

1. Economic and social plans to implement small (40-100 liter) bioreactors in coconut farming communities.
2. Demonstration of a small bioreactor: includes pressing oil, bioreactor operation, biodiesel purification, and glycerol (waste product) usage.
3. Identification and potential utilization of multiple oil feedstocks including coconut oil, palm oil, algae, and jatropha. Identification of any reactants that must be imported.
4. Development of operating manuals for oil press, bioreactor operation, and biodiesel purification/utilization.
5. Presentation materials (posters and electronic information) for government, communities, and local high schools that describe the entire biodiesel process- including technical issues.
6. Implementation of one small-scale biodiesel processing facility in a local community

7. Interaction of engineering students with businesses to identify future engineering projects.
8. Interaction with Liahona school to assess potential of future technical training courses.
9. Large-scale economic and schematic design of a biodiesel facility with recommendations. Future directions would likely need to be with a large-scale design facility. [This aspect was performed by a senior chemical engineering design class, and is not covered in this paper]
10. Facilitation of plans for future engineering interactions between engineering students and Tonga.

During the visit to Tonga, the professors and students will work with civic and business leaders to establish future internship opportunities for students to work on identified "mini" projects with associated technical training. For example, spring water is currently available in Tonga but this resource is not being bottled. Some of the projects may not be connected to current businesses but may involve other aspects of Tonga such as coconut utilization in the home. In addition to the "mini" projects, implementation of a biodiesel program would provide continual internship opportunities for students. The potential also exists for working with the Liahona High School in Tonga to develop technical training courses as needed.

Assessment and Impact

A very important aspect of the course and project is the assessment of how this project impacts students and faculty as related to the five components of enhancing global awareness, innovation, leadership, technical excellence, and character. These components have been identified as important attributes for engineering students at the university. At the end of the course, civic, religious, and business leaders will be asked for input on the student's interactions relating to their work and their cultural integration. Faculty will be asked for input on the student's abilities related to the technical aspects of the projects. In addition, dissemination of the student's experiences and projects (social and technical) will be presented at conferences (e.g. EWB, AIChE, and ASEE conferences) and submitted to peer-reviewed publications.

This project will have a high potential impact on students/faculty and the people of Tonga. Undergraduate students will gain experience in leadership, global awareness, innovation, character development, and technical excellence as they work on the various projects. Undergraduates will also have the opportunity to solidify engineering principles through applying the principles in <u>real-life situations</u> while working with <u>multiple</u> experienced faculty and other professionals. The students will experience cross-disciplinary study with other engineers by working with different cultures in technical and social settings. They will also learn the importance of non-technical aspects of the projects by learning of social, economic, and cultural impacts of technical decisions. The college will also benefit by increasing the colleges' service and visibility to the community. Global engineering projects will likely attract diverse, high-quality applicants by offering them the chance to engage in research and design on topics which are socially-relevant and through which they can make a difference. This is particularly true in attracting more women; the course currently has 22% females, while elsewhere in the college, female enrollment is closer to 10%. All of these potential impacts will be assessed following the visit to Tonga and the lessons learned will be incorporated into future offerings of the course.

In a mid-semester assessment, over 67% of the students agreed that they did not have sufficient training thus far in their undergraduate studies to solve such open-ended problems as the ones they were faced with in this class. 50% of students were frustrated at the beginning of the course at the open-endedness of the problems; however, 70% of students said they had increased their confidence in solving open-ended problems throughout the course.

94% of students said they had not previously had opportunities to work on multidisciplinary teams that involved multiple engineering disciplines. However 80% said that this class helped increase their appreciation for the value added by multi-disciplinary teams. 88% said that before this class, they did not realize the impact that engineering could have to serve mankind and to improve the human condition.

As one student explained, "At first I was only interested in the class because they were going on a trip to Tonga, however, participating in this project has led me to the realization of how *my* unique skills, and *my* contribution can really affect the world around me." Students said that some of their biggest rewards from the class are "Making decisions, moving forward and seeing it all come together!" and "Making *real* progress by overcoming challenges that at first seemed hopeless".

The main concerns that students had after a mid-semester assessment, were that more communication between the teams was needed, overall project deadlines needed to be assigned by the professors, not by the students themselves, and they wanted the mentors to play a more active role. The class was initially designed to be a "hands-off" environment for the professors and mentors, giving the students the opportunity to pro-actively determine internal deadlines, the details of the problems and ways to find them. The mentors and professors were available always, but students had to actively seek them out. This structure is something that students are not used to, and had a hard time adjusting to.

Key lessons learned to be implemented in next years class, are that more structure and class instruction upfront are needed. This will give students the "tool-kit" necessary to solve open-ended problems. In addition, mentors will establish overall project timelines and set up a weekly meeting between groups to communicate and update each other on the progress. When students are left to do this on their own, communication between groups was literally non-existent. In addition, we would recommend a cultural background during the first two weeks of the semester, and then work on the technical aspects and implementation. Other details of the assessment and student comments are given in Appendix A.

References

1. "A World-Class Act", Thomas K. Grose, *Prism,* American Society for Engineering Education (ASEE), September 2004.
2. "To the Rescue", Anna Mulrine, *Prism*, American Society for Engineering Education (ASEE), March 2006.

3. "Student engineers take stories of their work in poor regions to NYC", David Brand, The Cornell Chronicle, May 6, 2004.

Appendix A

Ch En 498R Mid-Semester Assessment
Global Projects in Engineering and Technology

Please rate the following:	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Open-ended problems					
1. I have had multiple opportunities in my undergraduate courses to solve open-ended problems	1	3	4	7	1
2. I have been sufficiently prepared to solve open-ended problems like the one presented in this course		3	2	10	
3. I was frustrated at the beginning of this course with the open-endedness and unknown aspects of the project	2	4	2	7	1
4. Since beginning this course, I have increased my confidence in solving large open-ended problems	1		4	10	1
5. I have had the opportunity to innovate on this project		3	5	6	2
Communication					
6. My team has effectively communicated with other teams		6	5	5	
7. My team has worked well together		1	2	10	3
8. Email has been an effective communication tool for interacting among my own team			5	10	1
9. Email has been an effective communication tool for interacting among other teams		3	9	3	
10. My mentor has been readily available and has been very helpful in providing advice		3	3	7	3
11. I have received requested information from other teams in a timely fashion.		5	10	1	
Interdisciplinary teams					
12. I have had multiple opportunities in previous engineering courses to work on projects with students from other engineering disciplines.	12	3			1
13. Since beginning this course, I have increased my appreciation for the contributions provided from engineers of different disciplines	1	2		11	2
14. Since beginning this course, I have increased my awareness of the value of multi-disciplinary engineering teams in solving problems	1	2	2	7	4
15. Since beginning this course, I have increased my confidence in working on projects involving areas outside of my	1	3	3	7	2

discipline or training					
16. I have learned new leadership skills since working on this project	1	3	2	7	3

Course structure					
17. The expectations of this course are clearly articulated		5	5	4	2
18. In-class team meetings have been productive		3	1	10	2
19. The workload is appropriate for this course		3	5	6	4
20. Completing a "real-world" project from which I will see the application has increased my desire for completing the project				7	9
Outreach/Global opportunities					
21. Since beginning this course, I have increased my desire to utilize my engineering skills/abilities to help others	1	1	2	8	4
22. Before EWB and this course was organized, opportunities for utilizing my engineering skills to serve mankind in a humanitarian project were not as apparent	1	1		9	5
23. Completing a global project has increased my abilities and confidence in functioning in a global environment.	1		2	10	3
24. While working on the project, I have not had any ethical dilemmas occur.	1	2	2	7	4

If any, what are the major differences between your initial perceptions of the course and the way in which the course has been conducted so far?

- It was definitely too fast paced initially, too much busy work, I think the revised schedule helped
- I expected more structure and instruction, thou I see why it is the way it is
- It was more open than I expected, but I did expect it to be very open
- I expected the coursework to be more technical, perhaps this is due to my group assignment
- The course expectations and even project goal was not very clear, this made it hard to work in our team as we didn't know our end goal
- I was expecting a little larger scope with more direction
- More instruction from professors and special guests – I expected most of the time spent in groups would be spent outside of class
- I initially believed that we, as a class, would be physically creating our own biodiesel reactor, not working on small aspects of a purchased one
- The only main differences is that the groups seem to function too independently
- I thought it would be a little more structured and answers would be more apparent

- I think the course has run the way I initially perceived, but I have been surprised at the complexity of the problem and the difficulty of the actual implementation
- It was a lot less organized that I thought it was going to be

What key aspects have you learned in the class so far?

- Working with a team
- The importance of setting and working for a deadline
- Organization is extremely important in a team
- Communication is critical! Don't drown yourself with unnecessary infrastructure!
- Good communication/teamwork help the work progress much smoother
- Mostly what I have learned is how to work better with people, some technical learning
- Interdisciplinary skills and cooperation
- All engineering disciplines and even other outside major are needed to complete a whole project
- Interteam cooperation is hard and takes effort
- Sense of urgency and spirit of cooperation, ownership in our part of the project
- Goal setting communication
- Working with other teams can be helpful and cause more problems (i.e. if the other team doesn't do their job)
- The importance of initially doing your research first before taking on a project, I feel that before EWB picked this project they should have scoped it out better and had more infrastructure set up in Tonga for us to work with
- The importance of coordinating and delegating work among the various teams and team members (especially the importance of giving specific assignments; also, no problem is as simple as it seems
- How to work as a team, how to delegate responsibilities – trust others

What have been your biggest challenges?

- Less experience leadership, group members need to feel important
- Buckling down and structuring my individual efforts, finding direction and obtaining information about Tonga, though this is getting better
- Getting information about the prices of oils and byproducts, getting everyone organized and making sure we're all on the same page (especially with GoogleDocs & such)
- Understanding what I should be working on – both as a team and individually
- Coordinating work within our team to the work of other teams, and all the teams combined
- We don't have any coconut oil or coconut oil biodiesel to work with and we don't know when we will
- Communicating with other groups; know what to research/do
- Working with other teams, defining the scope of our part of the project
- Communicating effectively within my own group, learning when to delegate and when not to
- Finding ways in which my engineering background applies to the task at hand
- Finding out enough to work on next step
- There is just too much to solve all the problems!!

- Running enough reactions to collect enough data and to find problems with reactor we can fix
- Getting information about Tonga, communicating with people with whom project applies (Tonga)
- Unforeseen technical complications with the reaction, figuring out how to make the process simple enough for Tonga
- Finding time – trying to figure out what we are supposed to be doing

What have been your biggest rewards?

- Making real progress by overcoming challenges that at first seemed hopeless
- Meeting with the other groups and discovering ways we can help them and eliminate redundancies
- Seeing all the pieces we worked on start coming together
- Seeing the reactor in the UO lab and all the oil donated
- What I have learned about the biodiesel production process, being directly involved, I know I will be able to remember what I have learned
- Feeling like I am making a difference
- Friends and learning to work together
- Seeing the team reach is milestones
- Association with many talented peers, real world experience in the handling and resolution of problems
- First test of real experimental results
- Solving problems
- Having to find solutions to problems and making a reactor that can work in Tonga
- The satisfaction of service, see progress and build model from scratch
- Seeing first hand the production of biodiesel fuel from vegetable oil, learning more about the people of tong and the prospect of traveling to the that part of the world, learning there from first hand experience and making a small contribution to their economy
- Making decisions, moving forward and seeing it all come together

What do you hope to gain out of the class?

- Make the world a better place
- A great service opportunity, open-ended problems, global and inter-disciplinary experience
- To know that the work I did has helped the people in Tonga
- I am seriously considering continuing with EWB-type projects for the rest of my life. I hope that this course, especially down to Tonga, will confirm or refute this plan
- A better understanding of the realistic impacts a team of engineers can have on a developing community
- I hope this project will be successful in Tonga
- A greater desire to serve mankind
- Experience in implementing solutions to real world problems
- Opportunity to learn how to serve, hose use available resources effectively. Ability to learn how to manage groups
- Experience and an enjoyable real-world project results

- Experience
- An appreciation of how a team works, and how teams working together. The ability to solve a real world problem and help others
- Appreciation for the use of engineering skills to serve
- To see a real-world, beneficial, chemical engineering process implemented in Tonga for the benefit of the people there. A greater exposure to and appreciation for the people of Tonga. A better understanding of this interesting alternative fuel.
- How to work in a team of engineers and apply engineering principles

Please list any missing aspects of the course that would be beneficial to incorporate in a future course (or later in the semester)

- Meetings between team leaders! Continuous short segments of structured large group discussions to help bring everyone back to the big picture and update on the overall progress
- Maybe a class website where we can read research and/or progress reports done by other teams so we know where everyone is at
- More required reading. Have one or two articles for each team to read. This would serve as a common basis within groups.
- More involvement of mentors in our projects
- Team liaison meetings (once a week)
- Team leader meeting where all the teams go through a design review
- More instruction to learn tools to deal with open-ended problems, overall project timelines, not established by groups
- More immediate feedback from the mentors
- More direction, more information at the beginning, more knowledge of "what" exactly the class would cover before registering
- I think more general and important details should have been nailed down before the class began by the mentors – such as what exactly doing in Tonga? What are our goals? Who will we be working with?
- Make the class more organized, it seems that everything is being organized last minute