Future Leaders in Technology and Engineering
(FLiTE)

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Abstract

Future Leaders in Technology and Engineering (FLiTE) is a project-based educational enrichment program that addresses the disparities in education faced by low income and minority students. We plan to work with 12 students from Cambridge Rindge and Latin for three weeks in January 2005. Our program includes traditional math and science lectures and explores these concepts through a group project. However, what distinguishes FLiTE from other educational enrichment programs is that FLiTE focuses on leadership development in science, technology, engineering and math (STEM) and helps the students to understand the relationship between the STEM fields and public policy. Throughout the three weeks, the students will be introduced to several guest speakers who are leaders in their fields and using their skills to influence public policy and encourage change within their own community. We are striving to dispel the notion that these fields are reserved for an elite few and instead to reveal to the students the ability they have to be original, creative, and innovative. By introducing them to highly technical disciplines, we hope to encourage the students to take ownership of these fields, so that they feel enabled to use these skills to promote change within their own community.

FLiTE is scheduled to begin on January 16 and to end on February 6. Recruitment and admission for the program will be conducted in early December 2005. The program will cost approximately $4,600. The students will meet with project coordinators after school for ninety minutes, Monday through Thursday at Cambridge Rindge and Latin High School. On Saturdays, the students will attend four-hour workshops at MIT, where they will construct their project.

Our team is composed of five undergraduates from the Massachusetts Institute of Technology. With diverse technical backgrounds, we are eager to use our knowledge to educate our surrounding community.

Introduction

In 2000, over 75 percent of African American and Hispanic tenth grade students in Massachusetts failed both the math portions of the MCAS exam; whereas less than 40 percent of their White and Asian counterparts failed the same exams. There exists an alarming racial disparity within the educational system in Massachusetts. Minority students are not being engaged in the fields of math and science. The schools are failing to demonstrate to theses students how they can use their education to impact their everyday lives, leaving the students feeling disengaged and uninterested in school. The community is failing these students, restricting not only their educational opportunities, but also their future career options. These students do not have equal access to resources that are critical for their educational development, and their math and science skills are far behind their peers, excluding them from careers in math, science, and technology.

Project Plan

We will recruit minority students from Cambridge Rindge and Latin through a comprehensive application process in December 2005. (See Appendix A.) Accepted students will be notified through mail and by telephone on 2 January 2006. We will meet with the students after school, Mondays through Thursdays for ninety minutes. On Saturdays, we will hold four-hour workshops at MIT.

The theme for this year's program will be innovative and environmentally friendly transportation methods. The students will discuss the role of math and science in the development of environmental public policy. In accordance with this theme, the students will be given a design project that is an environmentally friendly alternative

form of transportation. The students will then assess the strengths and weaknesses of their

project while also considering the strengths and limitations of other forms of

transportation. Throughout the program, the relationship between the STEM fields and

policy will be reinforced through the engineering design process. The students' project

designs will not only be required to fit basic engineering criteria, but will also have to be

an environmentally viable solution.

The program will commence with an opening ceremony to be held on January 16,

where we will explain the project goals and the curriculum to the students and their

parents. Week one of the program introduces the project and the design process to the

students. During these sessions, they will use the engineering peer review evaluation

process to assess the advantages and limitations of their designs. The students will also be

introduced to public policy, and will be given the chance to discuss the purpose and

significance of the selected project. During this first week, we would like to illustrate the

relationship between the STEM fields and public policy. The second week extends the

design process into implementation, and emphasizes the roles of math and science in

technology. The final week examines the various uses of technology and emphasizes its

role in society. This week culminates on February 5, with final presentations. The final

presentation will be in a policy based format, where the students will present their

projects as though they are lobbying policy makers to adopt policy that is friendly to their

technology.

The program alternates traditional math and science lectures with modules

featuring SolidWorks[1] and Matlab[2]. The computer programs will be used to connect the

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[1] A program used in design, generally to create models.
[2] An application used to create programs used for data analysis and visualization.

classroom lessons to the project. Computers also play an important role in introducing to students various aspects of information technology. Studies have shown that lower income students lack sufficient exposure to technology, limiting their ability to pursue many careers options. One of the goals of our program is to begin to bridge the digital divide in Cambridge by making information technology a vital component of FLiTE. Appendix B outlines a more complete list of our weekly goals.

The students will be divided into groups of three or four and each group will design and construct an LTA (lighter-than-air vehicle). Design of the vehicle will take place in the after school sessions, while the LTAs will primarily be constructed at MIT during the Saturday sessions. An LTA, such as a blimp, uses buoyancy to produce lift. The students will use their current knowledge of math and science and other various engineering tools in order to conceive, design, implement and operate (CDIO) an LTA. The CDIO strategy, developed by the MIT department of aeronautics and astronautics, has shown to be very successful in teaching engineering students the basics of project design. The LTA is judged based on its speed, reliability, stability, control, strength and aesthetic value.

Through the design and construction of the LTA, the students will be given a perspective into the design process of engineers, while also gaining an appreciation of the value of team work and leadership. Each week a different student will be assigned the role of team leader. As team leader, he or she will be responsible for insuring that the team accomplishes assigned goals for that week. Leaders will also be responsible for the delegation of tasks and time management. At the end of each week, each team leader will meet with a project coordinator to give an update of their progress and to voice any

concerns. A more detailed explanation of the project description is included in Appendix C.

Lastly, the program helps the students envision future career goals. After identifying several different careers, we show the students ways they can apply the material through the perspectives of several guest speakers. The guest speakers offers the students tangible examples of individuals who are leaders in the STEM fields and who have used their skills to impact change within their local community and, in some cases, the international community. This helps them to envision possible career paths as well as to inspire them to take action in the future.

To improve the accessibility of the program, we will meet at Cambridge Rindge and Latin on week days. Saturday sessions will be held at MIT due to spatial needs. A summarized version of the curriculum is included in Appendix D.

To gauge the effectiveness of our program, we will remain in close contact with the students after the end of our three week session, requesting academic updates from them and offering them academic support throughout the semester. The information we will gather includes term grades, SAT scores and any academic concerns. We are currently investigating a second component of the program to be completed over the summer or in January 2007, as well as working with Nicole Stark in the Office of Engineering Programs to incorporate this program into an activity regularly offered to area high school students.

Impact of FLiTE

In promoting future leadership in the STEM fields, we hope to encourage students to take ownership of these fields so that they feel that they are able to use math and science skills to instigate policy changes within their own community. The program stresses the connection between the STEM fields and public policy. We hope that the students will begin to recognize the ways that math and science are incorporated in the policy decision that affect their daily lives. We want them to understand that these fields do not stand in isolation, but instead form the basis of many policy decisions. Our program aims to change the dominant perception that the STEM fields are reserved for an elite group. Instead, we hope to demonstrate to the students that they have the ability and potential to be original, creative, and innovative.

We will be targeting students from low income and minority families who show interest in the STEM fields, but lack resources and sources of motivation. Inciting the student's passion through the interactive project-based learning style, we will help them form their interests into achievable goals. In addition, by giving the students an exciting, new exposure to the STEM fields, we hope to raise their performance and interest in school. Many times students lose interest in education because they do not see any significance in the material. Giving the students a vision of how the knowledge they gain in school is relevant to society will help recapture their interest in learning. By combining this aspect with the interactive, team-building component of the project, the students will form a new appreciation for these fields, and will hopefully pursue a path that will allow them to become leaders in their prospective careers.

By instilling in the students the idea that these leadership positions are within

their reach, we can help them develop their own talents and abilities in order to become leaders within their disciplines and communities. The students will take with them the skills they have gained in our program, which will provide insight into how they can use these skills to create an impact within their local, and perhaps greater communities.

The program curriculum has been designed to encourage students to pursue a career in the STEM fields, but more importantly, it directs students to take the necessary steps toward becoming successful in any field, whether it be in math, science, public policy or any other discipline. After completing the program, the students will be able to recognize the connection between the basic math and science concepts and real world applications. Specifically, the final presentation provides the students with direct experience on how math, science, and technology can be used to mold public policy, impacting change within their own lives and the greater community. In addition, it gives the students an opportunity to share their work with their parents and emphasizes the importance of effective communication in the STEM fields.

We would like to demonstrate the value of learning by teaching them how to generate ideas to solve problems. We hope to build a community of academic support for these students, so that they remain engaged in STEM fields and their application after the completion of the program.. More importantly, we hope to offer them resources with which they can further their education. By encouraging the students to take ownership of their education, we hope they will use knowledge as a tool to enrich and empower themselves. We want them to understand that they have the potential to change the world around them.

Goals of FLiTE

FLiTE has a dual objective. We hope to not only strengthen the student's skills in the STEM fields, but also to help students understand the relationship between public policy and technology. We will demonstrate to the students through lectures and guest speakers the direct impact that the STEM fields have on public policy, affecting their everyday lives. This program will expose high-school students with limited access to MIT's resources.   Many of the students have lived in the area for years, but have never stepped foot inside the Institute. Simply having a connection to MIT can stimulate the students' interest in higher education. Through this program, we can help MIT in its continual effort to reach out to the community.

Challenges

Effectiveness of our program is primarily limited by the students' interest in the material. If we fail to engage the students' interest, then it will be difficult to teach them basic concepts and almost impossible to inspire them in their career path. To combat this, our selection process will need to be conducted rigorously, seeking students that are eager to improve their academic standing, but more importantly those that are interested in learning and creating.

A secondary limitation is the potential gaps in the students' math and science education. While the curriculum is built on simple concepts, we must assume some basic knowledge in math and science. Due to the rigorous schedule, we will not have a large amount of time to individually tutor the students if they have high deficiencies in these subject areas.

Finally, our ability to secure access to resources both within Cambridge Rindge and Latin and MIT, may limit our success. We are heavily dependent on teacher support within the high school as well as support from MIT administration and faculty. However, through our contacts both within the community and at MIT, we are receiving positive feedback and support for our project.

Funding

Funding for this program will be necessary to supply educational materials for the classroom as well as lab materials for their projects. In addition, the students will each be given a laptop for the duration of the program. The laptops are necessary for the students learn how to use the engineering software and have been donated by MIT.

Because we will be keeping the students after school, we will need to provide lunches and snacks. The weekday sessions will be held at the schools, and the Saturday sessions will be held at MIT, so the staff will also need transportation to and from the schools, along with our teaching equipment. We will also need funding to reserve rooms at MIT for the introduction and presentations.

In total, the program will cost $5,500. For an itemized budget please see Appendix E.

FLiTE Project Team

Our group is composed of five upper-class students at MIT, majoring in a wide spectrum of fields. Most of our group has experience working in programs that teach and/or mentor youth. Having previous experience teaching and mentoring students of

this age is extremely important for understanding what interests and motivates the students.

Jesus Alvarez

Jesus is a third-year, Electrical Engineer student from Puerto Rico. Experiences with the Boy Scouts throughout his primary and secondary education gave him an understanding of project-based learning. In addition, he was involved with teaching mentally handicapped children at the Instituto Psicopedagogico de Puerto Rico. Jesus' enthusiastic personality will contribute to a success in relaying the information to the high school students..

Tabitha Bonilla

A junior, Tabitha is double majoring in Biology and Political Science. Since high school, she has worked as a tutor through several different programs. Most recently, she served as a residential counselor and teaching assistant for the Minority Introduction to Technology, Engineering, Entrepreneurship and Science (MITE^{2}S) program at MIT. In addition to teaching a bi-weekly class, she acted as a pre-college counselor to several of the high-school juniors enrolled in the program. Her experience in MITE^{2}S has inspired her to work with other programs, including FLiTE, to inspire change within the local community.

Yamicia Connor

Yamicia is studying chemical engineering and biology and minoring in

Biomedical Technology. Other interests focus on public policy and education. Her future career goals include medicine and academia. Currently, Yamicia is an instructor in MIT's Saturday Engineering Enrichment and Discover (SEED) Academy, teaching high school juniors chemical engineering basics

Yonatan Tekleab

Yonatan will graduate from MIT in February with a degree in Aeronautical and Astronautical Engineering. His interests include research in aerospace propulsion systems and also teaching/mentoring young students. Yonatan has worked as a tutor with many programs such as MIT's Interphase summer program, SEED Academy, and two MIT classes. He has worked as a tutor at local community centers and at the MIT Tutorial Services Room (TSR).

Etienne Toussaint

Etienne is in his third year as a Mechanical Engineering major. In addition,, Etienne is concentrating in Urban Studies and Planning and minoring in Economics. He is confident that exploring these fields will allow him to not only learn about the physical structures in society, but also the social, economic, political, and technological forces that give meaning to the everyday lives of men and women in residential, work, and recreational settings. Etienne has engaged in tutoring and mentoring programs since high school and is eager to combine the skills that he learned as a mentor with his technical education.

Supervisor

Our supervisor for this project is Tobie Weiner, an undergraduate administrator in the department of Political Science. Tobie has been working with us since the conception of this project in January 2005. She will be available as an ideas consultant and will help us manage the details of the program through the semester and over IAP.

Appendix A: **FLiTE Application**

Future Leaders in Technology and Engineering (FLiTE) is a project-based educational enrichment program that addresses the disparities in education faced by low income and minority students. We plan to work with 12 students in their second year at Cambridge Rindge and Latin for three weeks in January 2005. FLiTE includes traditional math and science lectures and explores these concepts through a group project. However, what distinguishes FLiTE from other educational enrichment programs is that FLiTE focuses on leadership development in science, technology, engineering and math (STEM). Throughout the three weeks, the students will be introduced to several guest speakers who are leaders in their fields. We are striving to dispel the notion that these fields are reserved for an elite few and instead to reveal to the students the ability they have to be original, creative, and innovative. By introducing them to highly technical disciplines, we hope to encourage the students to take ownership of these fields, so that they feel enabled to use these skills to promote change within their own community.

FLiTE is scheduled to begin on January 16 and to end on February 6. Recruitment and admission for the program will be conducted in early December 2005. The program will cost approximately $4,600. The students will meet with project coordinators after school for ninety minutes, Monday through Thursday at Cambridge Rindge and Latin High School. On Saturdays, the students will attend four-hour workshops at MIT, where they will construct their project. FLiTE will be coordinated by MIT undergraduates with diverse technical backgrounds.

Please read through all of the instructions carefully. Neatly print your answers in black or blue ink or type your responses. Submit your application form **to the main office of your school by 2 p.m. Tuesday, December 20**. If you have any questions, please email flite@mit.edu or call 406.788.9549. We will only accept **complete** applications, so make sure that you include the following items:

☐ Completed Student Application Form

☐ Parent/Guardian Support Form

☐ Math Teacher Evaluation Form
(sealed in a business envelope)

☐ Science Teacher Evaluation Form
(sealed in a business envelop)

☐ Copy of 8th grade report card

☐ Copy of 9th grade report card

☐ 8th Grade MCAS scores
(if you did not take the MCAS,
please explain on a separate sheet)

☐ Free Response and Essay

Part I: Applicant Form

General Information

Name:

Contact Information:

Who do you live with?

☐ My father ☐ My mother ☐ Both of my parents ☐ Guardian

Address:

Home phone:

Student cell phone:

Student email:

Personal Information:

Gender:

☐ Female ☐ Male

Birth date: **Birth place:**

Citizenship:

☐ American Citizen ☐ Permanent Resident

Ethnicity:

☐ African American ☐ Asian ☐ Caucasian ☐ Latino ☐ Native American

Languages spoken:

Language most frequently spoken at home:

Part II: Family Contact Information

☐ Father   ☐ Mother   ☐ Guardian

Name:

Address (If different):

Birthplace:

Citizenship:

Highest level of education achieved: **College Attended:**

☐ High School Diploma

☐ Associates Degree

☐ Bachelor's Degree

☐ Graduate Degree

☐ Father   ☐ Mother   ☐ Guardian

Name:

Address (If different):

Birthplace:

Citizenship:

Highest level of education achieved: **College Attended:**

☐ High School Diploma

☐ Associates Degree

☐ Bachelor's Degree

☐ Graduate Degree

Part III: Activities and Interests:

Please list any academic enrichment programs in which you have participated:
(Include the year and activities/courses taken)

Summer Programs:

Academic Year Programs:

Please list any academic activities in which you are involved:
(hobbies, sports, clubs, etc.)

What classes are you taking this semester?

Part IV: Free Response

What is your favorite class/subject area in school? Why?

Describe your career goals. What do you want to do in and after college?

Describe an invention you would design to make people's lives easier, healthier or safer. Be creative and explain how you came up with your idea.

What describes you? (You can list a few adjectives or write something more about your interests. It's up to you!)

Part V: Using a separate sheet of paper, write a 2 page essay answering the following question. Typed or hand written is ok.

Why do you want to participate in FLiTE? What skills, qualities and interests would you add to the program?

Part VI: Agreement

I understand that FLiTE is a three week long program for Cambridge Ringe and Latin students. If accepted, I intend to participate in all of the after-school and Saturday sessions. Because of a limited enrollment, I am aware that my attendance is crucial to the success of the entire program.

_____

Student Signature   Date

Appendix B: Curriculum Goals

Goals of 1st Week:
- Understand the peer review design and evaluation process
- 2/3 completion of framework of LTA
- Understand shop rules and basic techniques used in constructing the LTA
- Understand the basic theories of flight discussed in the first lecture
- Learn to work effectively as a group
- Understand the role of a group leader
- Understand the basic applications of engineering tools – SolidWorks®
- Understand the ways that engineering and science are used to solve social problems

Goals of 2nd Week:
- Understand basic surface area and volume calculations of 3-dimensional object
- Completion of the LTA
- Begin to recognize their potential role as leaders in their community
- Understand the force balances
- Make a connection between math and science fundamentals and technology

Goals of 3rd Week:
- Understand the basic applications of engineering tools – MatLab®
- Learn the components of a good presentation
- Make a convincing policy argument
- Create a PowerPoint® presentation to present their LTA during the competition
- Understand the trail and error process in the designing process
- Learn how to prepare themselves to apply to college
- Develop self efficacy skills that will lead to success in college

Appendix C: Project Description

The students will design a lighter-than-air vehicle (LTA). An LTA uses bouncy force to produce lift. This bouncy force is produced by a gas, contained within the body of the vehicle, which is less dense than air. For our project, we will be using helium, a non-volatile gas. The following design parameters must be considered when designing the LTA:

Structure

The students will first design the framework of the LTA. This is the most critical part of their design because a strong, durable support structure is necessary to contain the gas, to support the batteries, and to carry the control equipment and the payload[3]. The students will do simple truss analyses to verify the strength of their structures.

Materials

- Balsa wood
- Small motors
- Propellers
- Radio control appliance
- Servos
- String
- Epoxy, glue, tape, and other adhesives
- Weather balloons
- Helium gas

Balloons

The students will be using 1m diameter weather balloons as their helium containers. Based on their engineering analyses, the students will also choose the number of balloons to

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[3] Payload is defined as any additional weight carried by the vehicle that is not necessary for its basic function.

include in their design. This decision is dependent upon the overall weight of their structure and the weight of the payload. The teams will conduct simple force balance calculations to determine the amount of helium gas required to keep their LTA balanced. Using this value, the students will determine the number of balloons necessary for flight.

Propulsion System

The propulsion system will be designed based on two figures of merit: thrust required and stability. The thrust required will be due to the drag calculations computed based on the LTA overall design and geometry. The calculated thrust requirement will give each team an idea of how many motors they will use. The position and orientation of the motors has an impact on the stability of the aircraft. Stability calculations are beyond the scope of the project, so the students will be allowed to study the propulsion systems of other flying bodies to determine if they would like the motors to "pull" from the front, or "push" from the rear.

Control System

Remote control equipment will be used to control the LTA. The students will pilot the LTA using a remote control transmitter that will control the servos and the motor throttle. The students will have the decision of maneuvering their vehicles using control surfaces, differential thrust, or thrust vectoring. Maneuvering a vehicle using control surfaces means that the vehicle will deflect a surface at some distance from the center of mass, which will induce a moment on the vehicle, causing it to turn. Differential thrust uses multiple motors and varies the thrust of each motor so that there is an imbalance of forces acting on the body. This will cause a net moment and turn the LTA. Thrust vectoring uses the concept of reorienting the direction of

thrust. By changing the direction of the thrust relative to the LTA, this will induce a moment on the LTA, causing it to turn.

Judging Criteria

The judging criteria will be based on the following scoring algorithm:

$$SCORE = \frac{Payload\ Mass\ (grams)}{Flight\ time\ (seconds)}$$

Teams will optimize their designs by maximizing the amount of payload their vehicle carries and minimizing the time to complete the course.

Rules

The rules of the competition are as follows:

- No other materials are allowed beyond those listed on the materials list

- The LTA must complete the flight path as determined by the competition organizers

- The students may not be in physical contact with any portion of the LTA while it is in competition flight

- The students may not tamper with the LTA of any other team

Appendix D: Curriculum Outline

Kickoff: Monday, 16 January

      6:00 Students and parents arrive

      6:05 Buffet style dinner

      6:40 Icebreaker

      6:55 Presentation begins

          a. Introduce coordinators (5 minutes)
          b. Describe Project, Curriculum and Goals (15-20 minutes)
          c. Introduce staff and acknowledgments(10-15 minutes)
          d. Conclusion and Questions (5-10 minutes)

      7:50 Event ends

Week 1: LTA Design and Assembly

Tuesday, 17 January

      3:00 Informal Introduction and Discussion

      3:20 Introduce Engineering and Environment Policy/Group Discussions

          a. Explain engineering
          b. Discuss relevant environmental and energy issues in the local community
             Discuss the impact of social policy and the purpose of NGOs

      4:00 Introduce Project – Design of LTA

      4:15 Divide students into teams

      4:30 Class ends

Wednesday, 18 January

      3:00 Issue laptops

      3:15 Introduction to SolidWorks®

      4:30 Class ends

Thursday, 19 January

      3:00 Physics of Flight

          a. Unit Conversions
          b. Taking Measurements

      3:20 Design Process

          a. Students define project goals
          b. Figures of Merit (FOM)

      3:45 Group work on their design

      4:30 Class ends

Friday, 20 January

      3:00 SolidWorks® - CAD Modeling

      4:00 Peer Review Evaluation Process (PREP)

      4:20 Students prepare a task list before beginning shop work

      4:30 Class Ends

Saturday, 21 January
       9:30 Breakfast/ Review shop rules
     10:00 Shop training
     10:30 Work on project
      1:15 Lunch and project updates
      2:00 Students leave

Week 2: LTA Assembly and Analysis

Monday, 23 January
      3:00 Guest Speaker – engineering perspective
         a. Focusing on connections between engineering and social enterprise (ie how engineering can be used to make a positive change in the community)
         b. Demo or video incorporated

      4:00 Class Discussion – How does the demo/ presentation connect to policy
      4:30 Class ends

Tuesday, 24 January
      3:00 Math lecture – surface area and volume of simple 3D objects
      3:20 Math assignment
      4:00 Project feedback
      4:30 Class ends

Wednesday, 25 January
      3:00 College informational session
      3:45 Leadership workshop
      4:30 Class ends

Thursday, 26 January
      3:00 Physics lecture – force balance on LTA
      3:30 Physics assignment
      4:10 LTA strategy session
      4:30 Class Ends

Friday, 27 January
      3:00 Project – Phase II: How can you utilize your design to solve a problem in your community? Policy focus
         a. discuss one example as a class of something that can be done
      3:30 Break into teams to begin brainstorming ideas and working on presentation
      4:30 Class ends

Saturday, 28 January
    10:00   Breakfast/Review session goals
    10:30   Work
     1:30   Lunch/Group meetings
     2:30   Work session ends

Week 3: Project presentations

Monday, 30 January
     3:00   Matlab® lecture
     3:20   Matlab® assignment – assessment of LTA
     4:30   Class ends

Tuesday, 31 January:
     3:00   Self efficacy
     3:50   College skills
     4:30   Class ends

Wednesday, 1 February
     3:00   Final presentation PowerPoint and display board
     4:30   Class ends

Thursday, 2 February
     3:00   Conclude work on final presentations
     3:30   Guest speaker – Someone speaking from the policy perspective
            a. how do you make that connection between science and policy?
            b. Why is it important?
     4:30   Class ends

Saturday, 4 February
    10:00   Breakfast
    10:30   Test flight of LTA
    11:30   Performance assessment
    11:45   Snack
    12:00   Redesign and modification of LTA
     2:00   Session ends

Sunday, 5 February
     4:00   Parents and students arrive
     4:05   Light dinner
     4:25   Presentation begins
            a. Welcome parents
            b. Students introduce projects (7-8 minutes per team)
     5:00   Competition begins
     6:00   Concluding remarks
     6:15   Presentation ends