MU Information Technology Committee
Interdisciplinary Innovations Fund
Call for Proposals –June 2008
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**Chameleon Team**
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**College of Human Environmental Administrators for the Chameleon Student Project**

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Brief Description

    The University of Missouri-Columbia (MU) and Missouri University of Science and Technology (S&T) have teamed to develop an exciting energy conservation product.  The Chameleon project will produce an artificially intelligent residential energy management system designed to blend into its environment.  Upon successful completion of this project, the Chameleon home automation system will enable the average homeowner to conserve energy and save money by simply having the system installed in their home and not changing any of their daily activities. This total budget of the design, development, and implementation of Chameleon's prototypes is well over the budget for this funding opportunity, this proposal will focus on the educational partnerships required to develop the user interface for the system.

    This multi-university undergraduate student project incorporates engineering, architectural studies, and interior design students to develop a seamlessly integrated and highly functioning home automation system that requires no technical skills to operate. The underlying technology that enables the project is the IT capabilities of both universities which will enable weekly video-conference design meetings as well as internet accessible energy monitoring data available in real –time. In addition, students on both campuses utilize computer programs specific to their disciplines and learn program associated with other disciplines due to the multidisciplinary efforts required.  For example, S&T students use the computer program, Maui Solar, to estimate the size and placement of solar panels for home energy production. MU students often suggest solar energy production on their concept designs but do not know the details of how and where to place the modules. Working together with the computer program, students from both campuses are learning the importance of each disciplines' core software programs.

    The Chameleon team's proposal for the Interdisciplinary Innovation Fund meets the requirement from the MU Information Technology Committee.  The student led team is working to make the UM system a leader in energy conservation through the use of cutting edge technology and multidisciplinary design efforts that make the technology available to the average homeowner.

Goals and Objectives

The Chameleon "E-Team" has many goals and objectives for this project.  The overall short term goal is to design an automated system for the 2009 Solar House, while the long term goal is to adapt that system for the market.  In terms of this application, the focus is on the workings of the interdisciplinary Chameleon team itself including communication, education, and retention.  These goals are vital for the success of the Chameleon project in producing viable product, and will also prove beneficial for both students and educators far beyond this project.  Goals for communication involve promoting strong and constant involvement of all team members, both virtually and in person.  Education and learning goals will give students access to new technology and hands on experience in completing projects.  Retention goals will encourage participation and keep students excited about learning.  The success of these goals will be measured with surveys designed to evaluate student improvement in each of these areas.

1.  Improving teaching and learning
    a.  An objective of this project is to improve teaching by exposing educators to students of various disciplines with traditionally different learning styles.
    b.  An objective of this project is to expose students to related fields so that when they enter the industry they will be able to communicate easily with colleagues of different academic backgrounds.  It also promotes camaraderie between the disciplines.
2.  Improving student access to learning materials
    a.  An objective of this project is to utilize real-time energy usage data available on the Internet to derive a technological solution to home energy management.
3.  Increasing student engagement
    a.  An objective of this project is to leverage the energy crisis as a driver for the development of an energy management solution to possibly be employed by the general public in their homes.  The popularity and wide reaching audience is expected to increase student engagement.
4.  Supporting peer involvement and peer tutoring
    a.  An objective of this project is to support peer tutoring by involving two disparate disciplines.  In order to succeed, students from each discipline must involve and educate one another.
5.  Increasing retention
    a.  An objective of this project is to leverage the mass media appeal of the energy crisis to demonstrate these two professions as having a great societal impact, which has been shown to increase and maintain enrollment.
6.  Promoting success in courses
    a.  An objective of this project is to incorporate tasks of the project into the curriculum for the different universities.  The integration will produce greater excitement and success in coursework.
7.  Encouraging student learning beyond the classroom
    a.  An objective of this project is to encourage student learning beyond the classroom by its inclusion in the 2009 Solar Decathlon competition in Washington, D.C.

Description


In 2008 electric rates skyrocketed in the United States due to the cost of fossil fuels which provide 49.7% of our nation's power supply, according to the Energy Information Administration's "Annual Electric Generator Report." The average Californian paid 14.12 cents per KWh in May 2008 according to the Energy Information Administration (not considering additional charges for using energy at high demand times). Recent announcements of rate hikes reported in Easy Reader, such as the 25% increase by Southern California Edison, indicate the trend is not about to end. New and innovative ways to conserve electricity to offset this increase will be necessary not only for the average consumer's budget, but to decrease the growing demand of power in the U.S.

***The goal of this project*** is to design a user-friendly interface for the Chameleon energy management system under development by MU and S&T students. Chameleon will decrease residential energy usage with an artificially intelligent energy management system that calculates and executes energy needs in the most efficient manner. With increasing energy costs, Chameleon portends to be extremely feasible not only on an implementation scale but also on the emerging market of energy-conserving products. The project will cover from the user-interface design conceptualization through installation and market testing of an alpha prototype to improvements and development of a beta prototype. Specific to the alpha prototype installation and testing, Chameleon will be implemented in collaboration with the Show-Me Solar Decathlon Team in their 2009 entry being designed and built for the Department of Energy's 2009 Solar Decathlon[1]. Chameleon was chosen as the system's moniker because it is envisioned to integrate seamlessly within a building and its goal of reducing energy usage will produce no noticeable side-effects to the building occupant.

In recent years, significant research and development efforts have yielded progress in new methods of energy generation (e.g., improved wind turbines, higher efficiency solar cells, bio-based liquid fuels) and advancements to existing energy generation methods (e.g., cleaner burning coal fueled power plants, $CO_2$ sequestration, nuclear power plant reliability). However, few efforts have focused on consumer-level (or building end-user) efficiency and affordability. The proposed Chameleon system actively reduces energy consumption in residences while still providing the convenience of an automation system that can be operated with a minimum of technical skill.


**Multi-University Collaboration**
This project requires the collaboration of two universities (MU and S&T) to provide the expertise necessary to develop a fully functional user-friendly home automation system. The interdisciplinary communication required to develop successful Chameleon prototypes is very similar to the environment the students will be required to thrive in when they reach the professional design world. Further, the multi-campus collaboration promotes enthusiastic

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[1] The Solar Decathlon is a competition in which 20 teams of college and university students compete to design, build, and operate the most attractive, effective, and energy-efficient solar-powered house. The Solar Decathlon is also an event to which the public is invited to observe the powerful combination of solar energy, energy efficiency, and the best in home design. Refer to http://solardecathlon.org/about.html for more information.

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student interaction not only with their own campus but also with department and organizations across both campus communities.

The greatest hurdle in this process is to maintain good communication amongst the team members so that the final project showcases the needs and wants of all disciplines.  The students spend a lot of communication time on emails and phone calls between the campuses. However, like in the professional design world, the most reliable form of communication happens during their face-to-face meetings. The structure of their face-to-face meetings engages the three types of learners; visual, auditory, and kinesthetic (Silberman, 1996)[2]. These interactive meetings typically start with each discipline brainstorming keywords that need to be included in the project. Smaller, interdisciplinary groups then break out and sketch how these concepts will be integrated into the design.  For instance, when S&T students are explaining what a home automation system is and does, they talk about optimization of control and comfort systems. The smaller break out groups then conceptualize how the needs of that project integrate themselves into the home's design concept.

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[2] Silberman, Mel, "Active Learning: 101 Strategies to Teach Any Subject," Allyn & Bacon, Needham Heights, Massachusetts, 1996.

Management Plan


The Chameleon design project is an interdisciplinary, multi-campus project.  The establishment and maintenance of effective communication is the most critical factor to the management of the project.  The management plan for the project will include weekly teleconferences, bi-weekly face-to-face meetings, and continuous electronic communication.

Multidisciplinary committees will be established to tackle the design, construction, and evaluation of the Chameleon prototypes. These committees will be required to present their progress at each weekly teleconference and bi-weekly face-to-face meeting. The importance of the multidisciplinary committees is to maintain transparency and cohesiveness in the design of the system. For example, it is critical that engineering students participate with the architecture and interior design students on the aesthetics of the user-interface of the home automation system to ensure that creative design solutions are feasible with the technology available.

Integration into both the engineering and architectural studies curriculums at both universities is critical to the success of the project.  Not only does it provide the domain knowledge necessary for the students to work on the project, it also provides concrete deadlines for project deliverables helping to ensure its successful completion. Integrating the Chameleon alpha project's user-interface in to the design of a Solar Decathlon entry will be a component of MU's Architectural Studies Design Studio III in the fall of 2009. The Chameleon beta prototype will be the design project in the S&T Renewable Power System Design class in the spring of 2010.  This course, co-listed in the interdisciplinary, systems, and architectural engineering departments is delivered both on campus at S&T and via distance education.  The MU students registered in the spring 2010 Design Studio IV, will be encouraged to take the course and will be given instructor permission due to their working knowledge in the area.

- **June 2009**
    - Chameleon alpha prototype control system programming
    - Rolla engineering students will present the technical overview of how the Chameleon alpha prototype functions (Rolla, MO)
- **July 2009**
    - All students will participate in the installation of the Chameleon alpha prototype into the 2009 MU and S&T Solar Decathlon entry (Rolla, MO)
- **August 2009**
    - User interface for Chameleon alpha prototype will be selected and installed in 2009 MU and S&T Solar Decathlon entry
    - All students will participate in the testing of the Chameleon alpha prototype (Rolla, MO)
    - A procedure for collecting feedback from the general public at the Solar Decathlon will be developed for the user-interface
- **September 2009**
    - MU and S&T Solar Decathlon entry will be prepared for and transported to the 2009 Solar Decathlon in Washington DC

Management Plan

- **October 2009**
  - All students will prepare the Chameleon system for the competition (Washington, DC)
  - All students will present Chameleon to the general public and solicit feedback on the user interface design (Washington, DC)
  - Architecture and Interior Design students will present a variety of solutions for the user interface design for the Chameleon beta prototype during Design Studio III
- **November 2009**
  - The MU and S&T Solar Decathlon entry will be transported back to S&T
- **December 2009**
  - All student will evaluation the Decathlon feedback on the user-interface system and prepare the design project description for the Renewable Power System Design course
  - Architecture and Interior Design students will present the mock-ups for the user interface design for the Chameleon beta prototype during Design Studio III final critiques (Columbia, MO)
- **January 2010**
  - Present progress, outcomes, and expenditures to the MUITC at their January meeting (Columbia, MO)
  - General residential energy usage education presented to students in Renewable Power Systems Design class (Rolla, MO and online via distance education)
- **February 2010**
  - Chameleon Beta Prototype Project assigned to Renewable Power Systems Design class
  - Architecture and Interior Design students will present the mock-ups for the user interface design for the Chameleon beta prototype to Renewable Power Systems Design class (Rolla, MO)
  - Continued design team teleconferences and face-to-face meetings
- **March 2010**
  - Conceptual solutions presented and evaluated by students that address the feedback received at the Solar Decathlon
- **April 2010**
  - Present progress, outcomes, and expenditures to the MUITC at their April meeting (Columbia, MO)
  - Construction and installation of Chameleon beta prototype including new user interface design
- **May 2010**
  - Testing and evaluation of Chameleon beta prototype

Evaluation Criteria

The evaluation plan for the proposed interdisciplinary undergraduate project includes continuous assessment of student communication, increased student knowledge of different disciplines, and student retention. The multi-university qualitative and quantitative assessments range from student surveys to energy monitoring website access counts.

**Table 1: Chameleon Educational Assessment Plan**

| Project Goal | Educational Objectives | Student Learning Outcome - GL | Instrument | Method of Analysis |
|---|---|---|---|---|
| Improving teaching and learning | Improve students' communication between disciplines | Increase students' knowledge of jargon from other disciplines. | Survey, see Appendix A | Qualitative: Identification of disciplines' needs in the final project |
| Improving student access to learning materials | Provide real-time access to energy usage | Increase students' awareness of energy usage in every-day life. | a. Access monitoring<br>b. Survey, see Appendix A | Quantitative: Count number of web-site hits<br>Quantitative: Feedback about accessibility and usability of energy monitoring site |
| Increasing student engagement | Leverage energy crisis popularity in media to drive student learning | Students will understand the science behind the media reports. | Survey, see Appendix A | Qualitative: Identification of students' engagement/enjoyment of project |
| Supporting peer involvement | Involve students from disparate disciplines to educate one another about their role in the project | Increase students' ability to educate those outside their area of expertise | Survey, see Appendix A | Qualitative: Identification of student's perceived knowledge of other disciplines<br>Quantitative: Measure of number of students tutored on project related subject matter |
| Increasing retention | Increase student hands-on participation in project related to their daily lives | Increase students' ability to implement classroom theory | Record student attendance at meetings | Quantitative: Measure of attendance rate and retention |
| Promoting success in courses | Incorporate tasks of project into curriculum of involved departments | Increase student retention of energy issues as they relate to their courses of study | Record student attendance and grades in related course(s) | Quantitative: Measure of attendance rate, Measure of academic performance |
| Encouraging student learning beyond the classroom | Include project and its results in the 2009 Solar Decathlon Competition | Ability to educate the general public about energy issues in their fields as well as compete internationally | a. Survey, see Appendix A<br>b. Record student attendance at 2009 Solar Decathlon | Quantitative: Measure of attendance rate<br>Qualitative: Student's perception of increased environmental awareness and studies beyond the classroom |

Budget

The overall budget for the entire Chameleon home automation project is approximately $104,000 which can be seen in Appendix B. The funding for the project has been obtained by winning grants from both the Environmental Protection Agency (EPA), the Opportunities for Undergraduate Research (OURE) program at S&T, and discounts and donations from National Instruments, Siemens, and Whirlpool. The main expenditures in the overall project include the sensors, energy monitoring equipment, and the home appliances. The funds requested from the Interdisciplinary Innovations Fund, IIF, ($25,000) will be applied to the user-interface portion of the project. Because most of the costs in this area go toward the team collaboration efforts, it appears to be the best fit for the IFF to be applied.

The user-interface development expenses of the project involve meetings attended by all team members, as well as our information technology expenses. The project's goal to foster and improve relationships between engineers and architects is tried by the logistics of bringing the teams together for face-to-face meetings. The team utilizes social networking sites, email, and a variety of other online software to communicate, but the most beneficial for fostering relationships and knowledge transfer is the face-to-face bi-weekly meeting. This proposal requests funds from the MUITC to facilitate this interdisciplinary multi-campus project by funding student travel to the face-to-face meetings.

Another critical portion of the project is the Chameleon alpha prototype demonstration at the 2009 Solar Decathlon in Washington, DC. Based on previous Solar Decathlon's it is expected that over 500,000 members of the general public will attend and tour the MU and S&T solar house. Since the goal of the Chameleon system is to blend seamlessly into the home environment and be available to the general public, it is imperative that all members of the Chameleon team be present to solicit the feedback of this critical population sample.

Finally, the largest expense that the Chameleon team is asking the MUITC to consider funding is the purchase of interface hardware and development systems as well as software programs for the students. This software will enable the multi-disciplinary collaboration and peer tutoring described in the project objectives that are necessary for this project's success.

Conclusion

The Show-Me Solar Decathlon team started out with one goal; to win the 2009 Solar Decathlon competition. In 2008, we were awarded one of the Interdisciplinary Innovation Funds from the MUITC. The grant money allowed for easier pre-construction communication and collaboration between the two campuses that our team is based on. We believe that these efforts have made us a top competing team in this October's Solar Decathlon international competition.

However, during the evolution of the project the students have seen the need for more energy awareness in the end-user. While the solar decathlon house will make an impact on the visitors who tour it in Washington D.C. and in Rolla; the real impact will be if the average homeowner can make the connection between their everyday actions and the energy they consume. When the successful Chameleon prototype becomes a successful system that can be sold to any homeowner in Missouri and throughout the nation; then the interdisciplinary team will be a success.

In order to achieve this goal, the Chameleon team is asking the MUITC to fund the software and hardware requirements for the user interface development as well as facilitate the travel of team members to study the impact of their system in the 2009 Solar Decathlon competition. The award will also support continued collaboration between the campuses as they embark on the next step in improving energy awareness.

The recent Energy Summit, held at the University of Missouri's Columbia campus, stated that the UM System is embarking on the quest for cutting-edge research and development efforts in energy. This interdisciplinary, multi-campus team is excited about the support from the UM System and look forward to contributing our research that will make Missouri a leader in the future of powering America's homes.

Appendix A:  Student Survey

<p style="text-align: center;">Solar Decathlon Multi-disciplinary Survey</p>

Name

_____

Department

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1. What aspects from your discipline are required to be in the final design?


    a. Please explain the importance of these aspects to the overall project?


2. What aspects from your discipline would you like to be in the final design?


    a. Please explain the importance of these aspects to the overall project?


3. What aspects from your discipline do not need to be in the final design?


    a. Please explain why these aspects do not need to be in the final design?


4. What aspects from other disciplines should be required in the final design?

Appendix B:  Budget

**Overall Budget**                                    **$104,000**

Solar Village instrumentation (SDELC)          $40,000
Control System Hardware (EPA)                   $10,000
Sensors (S&T-OURE)                              $4,000
Appliances (Whirlpool)                          $25,000
Interface Design and Implementation (MUITC)     $25,000

**Detailed Business Operations as applied to Interdisciplinary Innovations Funding request**

|  | **Total** | **Budgeted** 25,000.00 |
|---|---|---|
| *Software* | | |
| Web Development Software | | 10,525.00 |
| Chameleon communication Software | | |
| | *Sub-total* | 10,525.00 |
| *Hardware* | | |
| Computer, touch screen, installation | | 9,358.36 |
| | *Sub-total* | 9,358.36 |
| *Solar Decathlon* | | |
| Hotel ($250/rm/night x 2 rooms x 2 nights) | | 1,000.00 |
| Air fair ($200/person x 8 people) | | 1,600.00 |
| | *Sub-total* | 2,600.00 |
| *Travel for team meetings* | | |
| 196 miles x $0.535/mile x 12months x 2 cars | | 2,516.64 |
| | *Sub-total* | 2,516.64 |