AC 2007-1211: USING ENGINEERING DESIGN CLASS TO DEVELOP A TRANSITIONAL TRAINING DEVICE FOR AVIATION STUDENTS

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Using Engineering Design Class to Develop a Transitional Training Device for Aviation Students

Abstract:

Primary Flight students encounter a negative transfer of information early in their flight training while learning to taxi (steer) an airplane in the airport environment. Non-pilots rely on using their hands to manipulate vehicular movement in automobiles. In aircraft, the control yoke does not become effective for turning the airplane until sufficient airflow is achieved while in flight. In addition, directional control on the ground is not achieved by movement of the ailerons or the elevator. In most general aviation aircraft, directional control on the ground is achieved by a steerable nose wheel and/or the deflection of the rudder. Early in the training process, students must overcome the strong desire to control the aircraft's movement by the use of control yoke inputs and instead, use the rudder pedals.

The challenge for freshman engineering students is to design a mechanical device that simulates the steerable nosewheel control system for use by pilots early in their training process. The engineering students were challenged to create specifications for a turning radius for the device. This involved investigation of how a steerable nosewheel operates on an actual airplane. Based on these specifications, the students were challenged to design a mechanical linkage system that allows the freedom of movement to meet these specifications.

This design project gives engineering students an opportunity to apply design principles to a practical project. The engineering students gain an understanding of work as a team; work with the client, and the sequence and process of design. Beginning pilots using the device gain an enhancement of motor skills that positively transfer to learning to steer the airplane.

This paper addresses the experiences of engineering and aviation science students to achieve these objectives.

I. Introduction:

The need for multidisciplinary cooperation in a global economy necessitates the need to introduce projects that increasingly engage students early in their freshman engineering year in college. With a dynamic market place, graduates need to be able to interact effectively in diverse fields. One important goal of multidisciplinary design is to identify the many solutions needed to solve a single problem while keeping in mind the many differing objectives of the overall project [4]. A multidisciplinary approach to engineering design is valuable in that it asks that students make certain that, "…advances in performance,… technology, or discipline(s), must be much more highly integrated than in the past" [3]. At the University of Maryland Eastern Shore, (UMES) a steady movement toward more complex design has been the experience of the first year engineering students enrolled in Introduction to Engineering Design class. The Engineering and Aviation Science Department uses its unique programs in Aviation Sciences as well as the basic engineering program as a spring board to seek out meaningful projects that compliment both units in the Department. Participating faculty have recognized a departure from past student designs with more sophisticated modifications to solve the same problem from the previous semester. Students partaking in the engineering exercise are forced to confront concepts outside of their normal field of expertise in the short span of a semester and make decisions on a cost and design schedule. This particular engineering project is multidisciplinary in two ways. First, it involves engineering students with the aviation science program faculty who asks that they study a problem that they are not necessarily familiar with. Secondly, the engineering and design of the project is to investigate alternative brakes and control systems. Because a decision made by one student module affects the plans of the other student module, the student's are forced to develop an internal management system to mitigate any conflicting systems.

II. Understanding the needs of the Freshman Pilot student

The challenge for the freshman engineering class was to address the needs of freshman professional pilot students who were just beginning flight training. This necessitated gaining an understanding of the needs of the freshman pilots and addressing these needs through the design of a training device. The designers were tasked with interacting with Aviation Science faculty and students in order to fully analyze these needs.

At the start of the semester, Aviation Science faculty were asked to attend an introductory class with the engineering students where they were interviewed by students to determine the specifications of such a device. On a bi-weekly basis, Aviation Sciences faculty were queried as to specific requirements and ideas were exchanged. The students were initially provided with a brief description of the problem by the Aviation Science faculty. This description stated: Early in a student pilot's primary training, a negative transfer of information occurs. From the first flight lesson, Certified Flight Instructors have the new student demonstrate the ability to steer the aircraft (taxi) by means of the aircraft's foot controlled rudder system. This new steering mechanism poses a challenge to most students who rely solely on their automotive driving experience. The result is that initial students tend to attempt to navigate the aircraft using the yoke (hand input device) and not the rudder pedal. Since the aircraft is not in flight and the ailerons are not effective at taxi speed, no change in aircraft direction is experienced and typically, the aircraft veers off the taxiway centerline only to be recovered by the instructor. To combat this negative transfer, instructors routinely have students place their hands on their laps or in other positions to reduce the urge to control the aircraft's movement via the control yoke.

III. Integration of Freshman Pilot Needs into Engineering Design

From this basic description of the problem, students were tasked with discovery of the issue and the design of a solution. The students were encouraged to treat the faculty members as if they were clients. Though this client-to-vendor interaction, students gained valuable experience in client relations and communications. This interaction also allowed the students a self-guided discovery of the issue. This method of self-discovery is preferable for adult learners to purely instructor-guided learning. In regards to adult learners, Henschke and Porterfield (2001) state that "educators will need to move their teaching and learning processes away from the 'instructional paradigm' toward the 'learning paradigm' thus encouraging self-directed learning." [2]

Further, Henschke (2000) found that highly effective adult learning programs shared specific characteristics. These characteristics included: self-directed learning, intellectual challenge and "active involvement in learning rather than passively listing to lecture" (Henschke, 2000). [1] This design project presented a more open and active approach than would a project directed solely by the instructor. Through repeated questioning, which became more specific as time progressed, the engineering design students were able to formulate a clear picture of the problem and integrate a solution into their design. Several design options were considered and the iterative process was key to the students' learning. These design considerations dealt with both material and cost associated with the choice of a final design.

IV. Team Formation and Project Management

Given that there were eleven students in the class, it was necessary to initiate a project that will utilize the entire group of students as a team and then segment the project into components that allow for maximum interaction among the students. The key to the grouping philosophy was to exploit the inherent interdependency of the groups in accomplishing the task. The students were therefore asked first to interact with the Aviation Science faculty (clients) and research the basic components of a plane control system. Furthermore, they were asked to design a linear motion tricycle-wheel vehicle where directional control is caused by left and right foot inputs similar to that found in general aviation aircraft. They were also required to improve upon last semester's efforts by redesigning the control linkage and input system. The project was then divided into the Rudder Pedal Group responsible for the redesign of the pedal system and a Differential Brakes System Group whose responsibility was to design the brake system. The students were given the freedom to choose which group they want to work on with a condition that both groups must be balanced. The process of managing the project started with the election of group leaders followed by weekly reports documenting group progress as well as individual team members' progress on assignments. Adjustments to the schedules were made based on the progress made by each group while evaluating the impact of their progress to the total project.

DESIGN OUTCOME IN PICTURES:

PEDAL

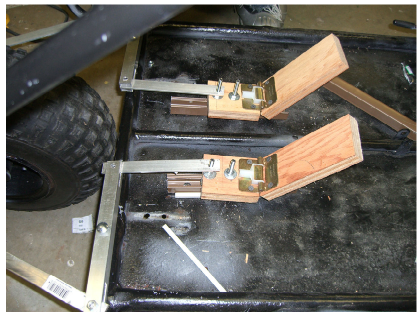

FIGURE 1

THE RUDDER PEDAL BEFORE...

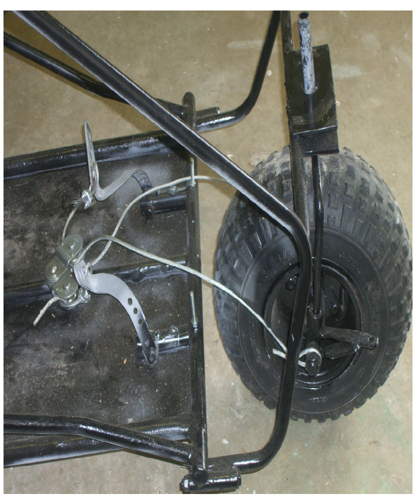

FIGURE 2

THE RUDDER PEDAL AFTER...

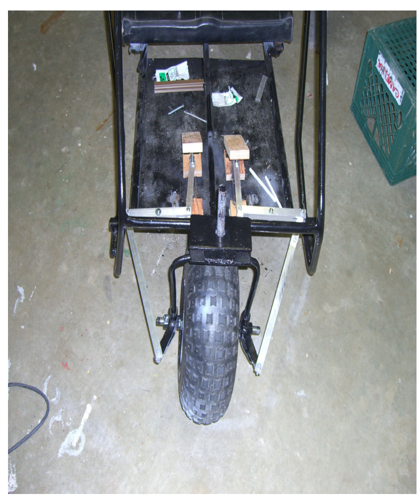

FIGURE 3

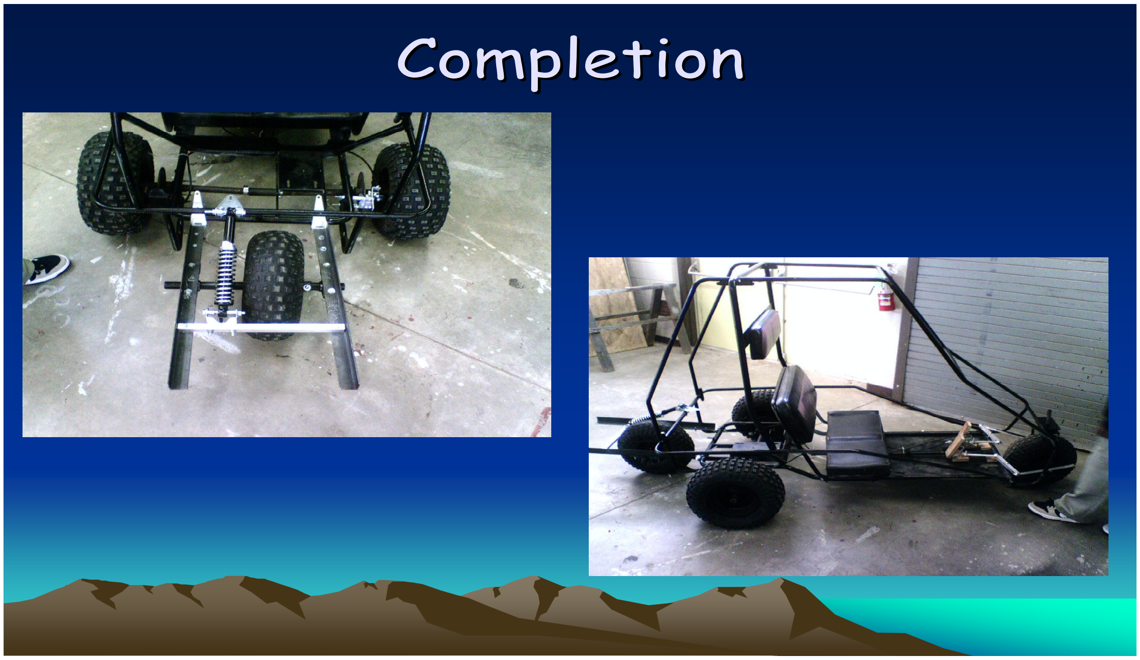

FIGURE 4

V. Students Learning Outcomes

The learning outcomes of interest were:

Team Experience

- Develop an awareness of the challenges arising in teamwork
- Demonstrate teamwork in the product realization process through a systematic design concept selection process involving participation of all team members.
- Demonstrate planning from conceptualization to the evaluation of the prototype.
- Engineering ethics.

Design Project:

- Demonstrate the understanding of the design process.
- Demonstrate competence in defining design objectives.
- Generate design concepts that meet design objectives.
- Manage the team and project effectively.

Software Applications

- Demonstrate the use of spreadsheets for calculation and data analysis.
- Show the capability to prepare graphs and charts with spreadsheets.
- Show capability to prepare power point presentations.

Communication Skills

- Design Briefings
    - ❖ Within the team format, present design review for the class using power point presentation.
    - ❖ Each team member demonstrates briefing skills.

- Design Reports
    - ❖ The team's design report is documented in a professional manner incorporating time schedules, costs, parts list, drawing, and an economic and environmental analysis.

One of the ways the project was assessed through weekly reports submitted by the individual students as well as group reports detailing the interaction between the group members. The critical component of these reports dealt with the problem-solving skills developed as they try to resolve design issues and deal with alternate designs within the constraints of the project. The reports from the students addressed the intended outcome stated above. The second approach was to allow the clients' interaction with the team to be graduated through out the semester such that the group's learning as they implement the project can be assessed. This is essential especially when the final project presentation takes place. About four or five faculty members judge the project from both the engineering design constraints, as well functionality in terms of meeting the Aviation Science Faculty objectives. Among the faculty are two Aviation Science faculty, two engineering faculty and or any other non-engineering faculty bringing a different view to the table.

VI. Lessons Learned

The results of this project were to be beneficial not only to beginning pilots, but also to the freshman engineering design students. Through the completion of this project and subsequent delivery of the product the students would gain a sense of accomplishment and fulfillment that is unlike that achieved in many classes. The realism of the task and the interactions with the "client" served to improve the students' skills in communication and personal interactions. The students' design was aimed at helping aviation science students correct a negative transfer of learning that takes place when steering an airplane by the use of its foot-controlled rudder system. A negative transfer occurs when someone experiences an automatic response to a cue based on information previously stored that is incorrect for the output needed for the present situation. [5] The clients' evaluation of the project as part of the students' grade provided valuable critic to the knowledge base of the students at the end of the semester. The comments from the students' presentations and reports show how much is learned through this process.

Spring 2006 Presentation Comments from the Freshman Engineering Class:

Key Issues
- Uncertainties
- Stress of weight to front axel
- Pedals strength
- Strength of welding
- Setbacks
- Resources
- Funding
- Fundamental Concepts

Completion
- Gained team experience
- Obtained stronger research skills
- Better independent thinking
- More efficient communication and analytical skills
- Goal accomplished

Fall 2006 Final Project Report Comments from the Freshman Engineering Class:

"In conclusion, our design did meet the requirements of our clients. We were able to create a design in ten weeks that allowed us to make a turn up to 10 to 12 degrees by using a rudder pedal; we also were able to convert the original braking system into a three wheel axle differential breaking system. During our ten week, there were many setbacks which we overcame. For example, money, damage of the go-kart, ordering of materials and many more obstacles listed above. Throughout this project, we gained communication skills, experience, design skills, and work shop safety, and learning to work as a team."

"Recommendation for the next group is to get a working engine on the go-kart. The pedals could have been made of something studier. Also, the seat needs to be raised up so it could be more comfortable, when a person uses the pedals to steer and break the vehicle. The brake cables need to be able to retract and not push back. The rods used for the rudder pedals could also be stronger."

Finally, the key to this approach is to select a practical problem from any field of interest. Once this is established, there should be a team of faculty from the chosen problem field who would then set the parameters and constraints which will guide both students' creativity and independence. The students will then interact with a team of instructors during the course of the semester to bounce their designs and difficulties with the aim of achieving the design objectives. When the project is completed, these faculty members will then evaluate the project with respect to the course stated objectives.

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