The Pennsylvania State University

The Graduate School

College of Education

LEARNING THROUGH THEIR EYES: A QUALITATIVE ANALYSIS OF THE STUDENT EXPERIENCE OF THE SAILPLANE CLASS AT PENN STATE

A Thesis in

Curriculum and Instruction

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

December 2010

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ABSTRACT

Learning through their eyes: A qualitative analysis of the student experience of the Sailplane class at Penn State

Qualitative research methods are used to evaluate experiential learning in the Sailplane class at the Pennsylvania State University from the perspective of student participants. Sailplane is a vertically integrated, project-based honors course in the Aerospace Department of the College of Engineering at Penn State. From entering freshmen to super-seniors, students work in mixed teams to design and build a full-scale sailplane. In the class, lectures on aerospace engineering topics are presented in support of the theoretical work of the design teams. In lab, project teams learn the hands-on skills needed for the fabrication of a full-scale sailplane. Data from a series of semi-formal interviews are used to explore how the social dynamics (such as a well-ordered social hierarchy and mutual accountability of upper- and lowerclassmen) support the learning of difficult aerospace engineering topics. Freshmen are exposed to theoretical and practical aspects of designing and building a sailplane that would otherwise be considered beyond their capability. As they mature in the discipline, this early exposure affords them an intuitive understanding of the complex concepts inherent to aerospace engineering.

In this study, data from interviews with student participants are used to examine how students learn to master highly technical subject matter, how they gain confidence in the rightness of their knowledge and what role the sailplane vehicle itself plays in this learning process. The students' expression of what is important – so often neglected in studies of the success of project-based courses – is here given prominence. From these accounts, it is clear that students move effortlessly among three learning environments: an academic environment, a semi-professional setting and an intensely social milieu. The students see little need to distinguish among the three.

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ACKNOWLEDGEMENTS

I feel a great debt of gratitude to the members of my advisory committee for their patience and support over the long duration of this project. Dr. Scott McDonald met with me and calmly provided the guidance and reassurance that I needed to continue this work when the conflicting pressures of family and professional life threatened to intervene. I am grateful for his ability to keep me headed in the right direction. I am grateful for the opportunity to work with Dr. Greg Kelly and to benefit from his uncanny ability to penetrate to the core of complex issues immediately. Dr. Tom Litzinger also showed a sustained interest in this project and I look forward to working with him, through his role as the Director of the Leonhard Center, to apply my new research skills to the betterment of engineering education at Penn State. I hope that the professional interactions, but also the friendships developed through this project can continue.

I would like to acknowledge the contribution of Sameer Honwad, a graduate student in Curriculum & Instruction, who volunteered to help in the administration of the interviews. Sameer was helpful in providing a forum for discussing the issues relating to the design of the study. He also performed two interviews that provide an interesting counterbalance to my own interviews.

Dr. Mark Maughmer and "Pipa" Bramesfeld have been most helpful in providing information and assistance for the administration of this study. I admire their passion for this class and for these students – that is, their passion for teaching.

Finally, I am filled with admiration for the students I encountered in the Sailplane project. They were articulate and dedicated. They put themselves forward because they

wanted me to know how important this class had been to their education. I hope that with this study I have lived up to their trust and told their story reliably. I have felt a tremendous responsibility to make sure that the accounts of their experience in Sailplane are put to the best possible use.

Chapter 1

Introduction

In the past twenty years, project-based courses (PBCs) on university campuses have progressed from a novelty to becoming an accepted feature of a dynamic engineering curriculum. This evolution has been part of a re-thinking of engineering education, the significance of which is still emerging. Psychological research in the 1960s and 1970s yielded new theories of how students mature during their college years. This led to new thinking on how students learn and thus to experimentation on methods of teaching and learning beyond the traditional lecture-based format. Funding agencies, including the National Science Foundation provided support for these innovations. In 2000, the Accreditation Board for Engineering and Technology (ABET) recognized the importance of including hands-on experience in an engineering curriculum, along with theoretical training. The concept of engineering education as an ordered series of lecture courses covering 'fundamental' topics began to be challenged. Particularly in fast-changing engineering disciplines, there was not sufficient time in a 4-year undergraduate program to cover both traditionally fundamental topics and the new knowledge that was revolutionizing these fields. To prepare students for the fast pace of change that would be a constant feature of their professional lives, more responsive engineering curricula were needed.

PBCs are one way that engineering curriculm designers are trying to meet this challenge. PBCs encourage an active attitude toward education and learning on the part of the students. In active-learning settings, Prince (Prince, 2004) relates that there is research evidence for more positive student attitudes, a deeper comprehension, longer knowledge retention and enhanced problem-solving skill. In a meta-study of 168 research studies between 1924 and 1997 comparing the relative efficacy of cooperative, competitive and individualistic learning, students who learn cooperatively showed advantages in knowledge acquisition, retention, accuracy, creativity in problem solving, and higher-level reasoning. (Smith, et al. 2005)

For the purposes of this study, we define a "project-based course" as having the following characteristics:

1. The central feature of the course is a project. The project is technically challenging, but the objective of the course is education, not technical accomplishment.
2. Responsibility for the design and execution of the project is fundamentally borne by the student participants.
3. Student participants learn discipline-specific knowledge and processes in a collaborative learning environment.
4. Guiding faculty oversee student efforts and present material of relevance to project work.1

Since the work of Boyer (1990) and Bransford, et al (2000), there has been renewed interest in active approaches to teaching and learning and a new definition of the function of university faculty. In Boyer's view, teaching is more than the simple laying out of principles. Curricula should be student-centered (rather than teacher-centric) and learning-centered rather than organized around subject matter. This shift in emphasis

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[1] A similar formulation applied by Barrows to K-12 education (cited in Smith, et al, 2005) includes:

- Learning is student-centered
- Learning occurs in small student groups.
- Teachers are facilitators or guides.
- Problems are the organizing focus and stimulus for learning
- Problems are the vehicle for the development of clinical problem-solving skills
- New information is acquired through self-directed learning.

calls for rich learning environments in which knowledge is constructed cooperatively in settings that include instruction, but which also recognize the social dimensions of learning. Edgerton wrote (in his 2001 Education White Paper, cited in (Smith, et al. 2005)):

> Throughout the whole enterprise, the core issue, in my view, is the mode of teaching and learning that is practiced. Learning 'about' things does not enable students to acquire the abilities and understanding they will need for the twenty-first century. We need new pedagogies of engagement that will turn out the kinds of resourceful, engaged workers and citizens that America now requires.

PBCs are attractive, because they are education-based and results-oriented. As above, advocates claim that PBC students not only learn the subject matter in a 'deeper' way, but that these students also approach problems differently. They exhibit 'expert behaviors' that generalize beyond the specific focus of the PBC. Both education and professional results are enhanced, according to those who argue for PBCs. These claims are hard to evaluate. Certainly traditional metrics (for instance test scores) fall short. In this study, my approach was to ask the students themselves how they have benefitted from this approach to learning, as exemplified by the Sailplane course in the Aerospace Engineering Department at Penn State University (Sailplane). I wanted to record the views of those close to the experience. How did *they* see learning take place and, more generally, in what ways did project-based learning contribute to their development as engineers.

In this study, semi-structured interviews were used to capture the perspectives of just over half of the students in Sailplane during the fall semester of 2005. At the time of these interviews, the Sailplane class had been in existence for ten years. The most senior student respondent had been in the program for five of those years. I also interviewed a student who had been in the course for just over a week. In addition to Sailplane students, I talked with the Head of the Aerospace Department and with Dr. Mark Maughmer, one of two originators of the Sailplane concept. Thus, this data set represents a broad sample of the Sailplane experience of that time.

Indeed, Fall 2005 represented a high point in the history of the class. Two projects were in process: The Falcon, a sailplane kit that had been donated to the class; and the EZ-build, a sailplane earlier designed and now being built entirely by the Sailplane class students. Although the work was ongoing, there was a sense that a chapter was about to end. The instructor for the course, Götz Bramesfeld (universally called ‘Pipa’ by colleagues and students alike) was about to finish his PhD and was making plans to leave Penn State. Eight seniors and super-seniors were due to graduate in the ensuing academic year. At the same time, there were fourteen freshmen -- an unusually high number. Thus, there was a sense of urgency to complete the parts of the sailplane that these seniors had designed and to pass on the accumulated knowledge that would allow the incoming freshmen to carry forward the remaining work.

I picked Sailplane for this study because of its long record of existence. A preliminary study (Wheeler, 2003) had convinced me that Sailplane students were eager to relate their experiences learning aerospace engineering in the class. Dr. Mark Maughmer and Pipa had assured me access to class activities and course records.

History of Sailplane

The Sailplane class began in the spring semester of 1991 as a place for students literally to get a feel for the aerospace concepts that they study theoretically in their lecture classes.

> The primary goals of the sailplane project are to produce a better engineer through a ‘hands-on’ environment, which motivates students, provides management and creative skill development and to give a realistic design experience that is completely integrated into their curriculum. (Maughmer & Jensen, 1992)

It was to provide students with a comprehensive view of the design, construction and testing of a flight vehicle in a vertically integrated class and lab.

The concept for the class was adapted from German extracurricular clubs (Akademische Fliegregruppen or “Akafliegs”) that have grown up alongside many German technical universities since the 1920s. The Akafliegs enjoy a close relationship with the German aerospace industry, which uses the clubs as a testing ground for design and materials innovations. Akafliegs offer students practical experience with the design, fabrication and flight testing of an aircraft – usually a sailplane. The clubs are popular despite the fact that participation requires such a great deal of time that the students often need extra years at the university to complete their degree requirements. (Maughmer, 1992)

With the inauguration of the Sailplane class at Penn State, Mark D. Maughmer and David W. Jensen strove to adapt the Akaflieg experience to the American university system. They felt that a vertically integrated lab (where seniors work together with freshmen across the wide array of aerospace subject areas, including aerodynamics, stability and control, structures, materials, fabrication and testing) would motivate students to pursue aerospace engineering careers. The past nineteen years have shown that they were right. The program is as popular today as it ever was, with 33 students registered in the fall of 2005. This number is generally acknowledged to be a maximum enrollment as decision-making and the social glue that holds the project together would be hard to maintain with more. Several students noted that the laboratory facilities were already barely sufficient to accommodate this number of students.

ECSEL

As mentioned above, institutional support for curriculum reforms in the 1990s was an important factor in the acceptance of PBCs into mainstream university classrooms and labs. Sailplane was well-timed to be a part of this movement. Early funding for Sailplane came through the NSF-funded Engineering Coalition of Schools for Excellence in Education and Leadership (ECSEL). Launched in 1990, ECSEL was one of the first of NSF's Engineering Education Coalitions (EEC) to be funded. Penn State was one of seven schools in that coalition. ECSEL had two stated goals:

1. transforming undergraduate engineering curricula, and
2. increasing the diversity of engineering graduates.

It approached these goals through "the imaginative integration of design activities throughout the educational pathways of our students." (ECSEL, nd)

ABET

The Accreditation Board for Engineering and Technology (now just ABET, Inc) began accrediting undergraduate engineering and technology programs in the 1930s. Since that time, ABET has provided a constant and authoritative basis for accreditation of such programs in the United States, even as the disciplines themselves have changed drastically. At first, the ABET approach was to stipulate (and evaluate) fundamental topics that such programs must include in order to be accredited. Obviously, the consequences of *not* being accredited by ABET were immense for the participating institutions. Therefore, ABET came to wield enormous influence on what and how engineering was taught in the USA for over half a century. In the 1990's, ABET decided to use this position of influence to provide leadership for moving toward a focus on outcomes, rather than rigid content requirements.

> In 1997, following nearly a decade of development, ABET adopted Engineering Criteria 2000 (EC2000), considered at the time a revolutionary approach to accreditation criteria. The revolution of EC2000 was its focus on what is learned rather than what is taught. At its core was the call for a continuous improvement process informed by the specific mission and goals of individual institutions and programs. Lacking the inflexibility of earlier accreditation criteria, EC2000 meant that ABET could enable program innovation rather than stifling it, as well as encourage new assessment processes and subsequent program improvement. (ABET History, nd)

ABET accreditation reviews occur every 6 years, so starting in the mid-90's, during the well-publicized approach of the new EC2000 guidelines, engineering programs recognized a tremendous opportunity, even a necessity, to try new approaches to teaching and to offer students opportunities beyond the traditional lecture courses. Some said that universities should provide students with opportunities for hands-on experience as part of the undergraduate educational program. (For example, see Finelli, et al, 2001.)

Since that time, capstone design classes, co-op programs, internships and project-based courses have become a part of most university engineering programs of study. Capstone design classes conform to the standard lecture-based format and so fit easily into established curricula. Co-op and intern programs typically take place in a work setting remote from university campus and so are accommodated by, but are not a part of the curriculum. Project-based courses provide students a way to apply their theoretical knowledge in a designed learning environment as part of the curriculum, often without the competitive pressures of lecture-based courses. Learning communities and collaborative educational settings incorporated a social dimension into the learning environment, acknowledging that learning is a social activity. They were inclusive, multi-disciplinary and supported different learning styles.

Under the new ABET guidelines, experimentation and innovation within the curriculum were expanded. Students could select learning environments that they thought were meaningful or appropriate for maximum learning. Sailplane, begun in 1991, was a part of this expansion. Laboratory classes could become more than a place to demonstrate lecture material. It became possible to offer students hands-on experiences with the leeway to experiment and explore – all within the credit-bearing curriculum.

My Experience/bias

I bring to this study an interest in project-based courses sustained through fifteen years of developing and running a project-based program in electrical engineering. The Student Projects Involving Rocket Investigation Techniques (SPIRIT) Program was begun in 1995 by Dr. Jack Mitchell, Dr. Charles Croskey and me. It is similar in size to the Sailplane course and several of our learning objectives were comparable. When we proposed the SPIRIT Program, we had several discussions with Dr. Maughmer in order to benefit from his experience with Sailplane. Both programs have as their focus vertically-integrated, long-term projects of a technically challenging nature. That challenge was of a scale beyond the ability of one person or even one team to complete. Small teams, organized by function, were accountable to each other for the completion of the work. At the same time, there are significant differences between the programs, as enumerated in Table 1-1 below.

Table 1-1. Differences between the Sailplane course and SPIRIT Undergraduate Sounding Rocket Program

<u>Sailplane</u>	<u>SPIRIT</u>
1. Internal organization only	1. Teams work with NASA engineers and partnering institutions
2. Students control work deadlines for their own educational purposes. Building a sailplane is a secondary goal.	2. Launch deadlines sometimes supersede educational goals
3. Students with similar interests in aerospace engineering joining together to learn and teach each other.	3. Payload work is multi-disciplinary, requiring EE's, Aero's, ME's, scientists, and publicists. As a result, the social dimension is diluted.
4. The Sailplane course is a significant part of the students' transcript – both in	4. SPIRIT plays less of a role in the students' academic record. There is a

the number of credits and in that Sailplane credits substitute for other courses required for graduation.	1-credit SPIRIT companion course that students can take repeatedly. Students may use these credits as a technical elective.
5. Focus on aeronautics	5. Focus on astronautics and atmospheric science
6. Based in Dept of Aerospace Engineering. Subject matter is related directly to learning aerospace principles and is aimed at a junior or senior level.	6. Based in Dept of Electrical Engineering. Lectures topics are determined by the dictates of the project, but include project management and professionalism subjects. No prior expertise is assumed.

While the Sailplane course and SPIRIT are structurally similar, they present different learning environments. Few students participated in both. The time requirements are great in each case. One of the few who was involved in both programs was interviewed for this study. That student said,

> Sailplane is very aeronautical. It teaches you the formulas. It teaches you what the parts of the plane are. It teaches you how to do composites, but SPIRIT is more space oriented. It's a completely different class, because it's more like hard timeline that you have to have this thing launched in June. You don't have the luxury of having time to be like, 'Oh, we'll find this out'. You have to find it out like *now*… [SPIRIT] really gives you a taste of the actual profession, whereas Sailplane gives you a taste of upper level college. (S04, lines 202 -304)

Despite the structural similarities between the courses and despite my stake in the success of PBCs at Penn State, I believe my perspective as a knowledgeable outsider to the workings of the Sailplane project is an important factor in this study.

“Success” in the context of PBCs

If curriculum designers are to have confidence in new approaches to engineering education, they must be convinced that these approaches are an improvement over tried and true methods. Yet test-based assessments fall short of the task of measuring success in this context. Proponents of alternative (to lecture-based) pedagogies claim that student-based learning affects several highly desirable factors, such as student confidence, expert behaviors, persistence to a degree, commitment to the profession, etc. These affects are difficult to measure quantitatively. As Pipa put it, “We want to get across to these students our motivation for being engineers.” Maughmer added: “The important thing is capturing enthusiasm for what [we] do.” He suggested that though the students may not see another sailplane in their professional lives, they will retain the curiosity, the facility with tools, analytical skills and confidence in themselves that they attain as a result of the Sailplane learning environment. (Personal conversation, June 2003.) The literature supports this contention. Astin’s large-scale correlational study of what matters in college…

> …found that two environmental factors were by far the most predictive of positive change in college students’ academic development, personal development, and satisfaction. These two factors – interaction among students and interaction between faculty and students -- carried by far the largest weights and affected more general education outcomes than any other environmental variables studied, including the curriculum content factors. (Cited in Smith, 2005, pp87-88.)

Pascarella and Terenzini, in their meta-study of “How College Affects Students”, said:

> Perhaps the strongest conclusion that can be made is the least surprising. Simply put the greater the student’s involvement or engagement in academic work or in the academic experience of college, the greater his or her level of knowledge acquisition and general cognitive development…a substantial amount of evidence indicates that there are instructional and programmatic interventions

> that not only increase a studen's active engagement in learning and academic work, but also enhance knowledge acquisition and some dimensions of both cognitive and psychosocial change. (Pascarella & Terenzini, 1991, p. 616.)

In an outcomes-based teaching environment, the assessment of learning becomes a central concern of the teacher. A simple inventory of individual concepts learned may be convenient for producing a single grade, but it does not take into account the breadth of hands-on experience that the students gain and which carry over to the professional workplace. We need methods of investigation that can support claims of success in reaching the program goals of the curriculum designers and the learning goals of students. In this work, I suggest that such a study should include the perspective of the student participants themselves. The students have direct experience of both of these outcomes. Although we do not assert that the student voice is sufficient for assessing these dual outcomes, we do suggest that the student voice provides evidence for success (or not) for progress toward both of these objectives. The direct expression of the experiences of the students contains the raw data we need to understand how to continue to improve the conditions for learning for the benefit of the students.

Chapter 2

Conceptual Framework

Experiential learning as a pedagogical method grew steadily, but slowly, for over a half century before expanding quickly in a number of divergent directions starting in the 1980s. What began as a reaction against the stilted learning environments of one-room schoolhouses at the beginning of the 20th century entered a period of intense experimentation and innovation.

Three theoretical threads that converged in the 1980's have contributed to the emergence of experiential learning as a pedagogical tool and set the stage for the developments that continue today:

1. The growth of experiential learning as a pedagogical method first emerged around the turn of the twentieth century and was given voice by John Dewey, the eminent education philosopher.
2. The development of theories of human development in the college years, as typified by Chickering and his seven vectors of psychosocial development, led to an increased focus on how students learn. Personality and cognitive development, as well as individual learning styles will have a determining effect on what is learned. This has led to a growing awareness that *how* a subject is taught will influence how a student learns. A great deal of research has been done in the last thirty years on what kinds of learning is desirable (for example, beyond rote learning, the ability to generalize learned experiences to novel situations and other

"expert behaviors"(Bransford, et al, 2000)) as well as how different populations (women, non-traditional students) learn best.

3. Finally, new theories of how to apply qualitative research methods to disciplines beyond the social sciences (including education), such as Strauss and Corbin's "Grounded theory" methodology (Strauss, 1998) provided a means for measuring outcomes of non-standard teaching methods.

All three of these areas of research have contributed to the emergence of a vision of what engineering education should be. Beginning in the 1990's, engineering departments began to adapt new methods of teaching in order to keep pace with rapidly changing requirements of the emerging information age. This trend to provide multiple learning environments and to include non-technical topics (such as teaming skills) as important elements of professional training has been encouraged through the initiatives of ABET, the body that certifies many engineering and technical programs across the country, including Penn State.

In this chapter, I provide an overview of these developments. Sailplane, begun in 1991, is both a product of these trends and a glittering example of their promise. Had Dr. Jenkins and Dr. Maughmer attempted to establish Sailplane just ten years before, they might not have found as receptive an audience. In this chapter, I review the literature on the particular aspects of the teaching philosophy that have relevance to Sailplane. In addition, I report on literature that is relevant to the methods of this study, such as my focus on the student voice as a source of data to represent the Sailplane experience.

Before I begin, I should make a comment on nomenclature. A number of names have been coined to refer to the non-traditional teaching methods I discuss here.

Experiential learning, collaborative learning, service learning, community service learning, project-based learning, project-centered learning, public action learning, active learning, cooperative learning, learning communities, among many others, all refer to techniques of active learning. There are differences among these many styles, based on the circumstances of their implementation or the particular outcomes that the authors wish to emphasize. All these methods refer to "interactive experiential learning" in that the active participation on the part of the student is seen as a central requirement that contributes to the teaching/learning outcomes. In many cases, they include a mixture of traditional lecture-based teaching along with the interactive or hands-on activities.

In this paper, I will use Dewey's term, experiential learning, to refer to the general practice of using directed experiences for pedagogical effect. This is contrasted to the traditional lecture-based approach – where the professor decides what is important for the students to learn and then delivers a well-ordered discourse on those topics. From the teacher's perspective, experiential learning means leading students through (and helping them process) a series of experiences that exemplify the topic to be taught. By this method, it is hoped, students will gain more than a theoretical knowledge of the subject matter. On the student's side, experiential learning means constructing knowledge by assimilating the new experiences into a framework of previous understanding of the subject. Thus, "constructivist" theory of learning is central to experiential learning.

Sailplane is a good example of what we will here call a "project-based course" in which the entire activity of the course (both lectures and hands-on work) is related to the design and fabrication of a technically challenging project. This focus on a particular project allows students to see the wide array of skills and disciplines that must come together in the design of a complex product like a sailplane. It also necessarily limits the set of topics that can be included. For instance, since the class is building a sailplane, the students must come to terms with many topics related to theory of flight, characteristics of materials, control mechanisms, fabrication techniques, stress analyses, etc. At the same time, they must go elsewhere to be introduced to orbital dynamics or space vehicle design – topics that are central to many aeronautical engineering curricula. A project-based course, therefore, allows an in-depth experience with one particular set of skills that are relevant to the project under study.

John Dewey and the rise of Experiential Learning

According to Karl Prince (Prince, 2004), the first reference to experiential learning comes from a practitioner, Colonel Parker, in 1883. However, it was John Dewey (1859 – 1952) who developed the concepts into a coherent philosophy of what came to be called progressive education. John Dewey was born in 1859 in Burlington, Vt. He graduated with a Doctor of Philosophy degree from newly established Johns Hopkins University in 1884. Dewey spent his academic career at the University of Michigan (1884 – 1888 and 1889 – 1894), the University of Minnesota (1888 – 1889), the University of Chicago (1894 – 1904) and Columbia University (1904 – 1930). He continued his prolific writing career as an emeritus professor until 1938.

During his tenure at the University of Chicago Dewey had been the Head of the Department of Philosophy, which included the study of philosophy, psychology and pedagogy. At his urging, the study of pedagogy was split from the Philosophy

Department. Dewey became the head of both departments. At the University of Chicago, he established an experimental school to test some of his theories of progressive education. He had an enormous influence on the American education in the 1920's. John Dewey wrote more than 40 books and hundreds of articles. He was active in politics and liberal causes. He was an editor of the *New Republic* and a founder of the American Association of University Professors.

Up until Dewey's time, the teaching of philosophy was intertwined with religious teaching. He was one of a new breed of lay professors of philosophy. He thought that education should consist of more than the rote learning of norms. "Dewey believed that school should teach students how to be problem-solvers by helping students learn how to think rather than simply learning rote lessons about large amounts of information. In Dewey's view, schools should focus on **judgment** rather than **knowledge** so that school children become adults who can "pass judgments pertinently and discriminatingly on the problems of human living" (Campbell, 1995. Original emphasis). He was associated with a branch of philosophy called "pragmatism" in which the truth or value of an idea lay in its usefulness in application to everyday problems. Dewey felt that there was a political (even patriotic) dimension to the importance of education in society. He thought of good education as fundamental to the functioning of a successful democracy. For the student, Dewey suggested that the outcome of education is *growth.* He felt that each student brings a unique set of skills and experiences to the classroom and that progressive education must be responsive to these individual circumstances if it is to reach its greatest potential. There can be no static set of teaching procedures because each student will take education in a different way. Rather, a teacher should be a guide, introducing students to appropriate activities that illustrate the subject matter and playing an active role in helping the student understand the significance of the experience:

> Students should be given to understand that they not only are *permitted* to act upon their own intellectual initiative, but that they are *expected* to do so, and that their ability to take hold of situations for themselves would be a more important factor in judging them than their following any particular set method or scheme… (cited in Archambault, 1964, p334.)

John Dewey occupies a central position in the development of education as a distinct area of study in America. In his wake, the *philosophy* as well as the *practice* of education became legitimate fields of study. In addition, the *psychology* of learning was seen to be relevant to effective education. More than mere training, education, in all its dimensions, was put forward as central to the very success of the Republic. Reaching our potential as a democratic nation would depend on an effective system of education, commonly available to all our citizens. (Dewey, 1916) His ideas continue to have relevance to the practice of education in this country today.

Theories of cognitive developmental psychology

In the first half of the 20th century, progress in the field of developmental psychology complemented the dialogue that Dewey and the other education theorists had begun on how children learn. While Sigmund Freud and Carl Jung established new theories of personality and personality analysis, Jean Piaget, building on the work of Jung, focused on how personality develops. He identified four stages of maturation through which a child progresses. These stages, correlated with age, are:

- Sensorimotor period (years 0 to 2) or infancy

- Preoperational period (years 2 to 7) or child
- Concrete operational period (years 7 to 12) or childhood
- Formal operational period (years 12 and up) or adolescent

("Piaget's Theory of Development". Nd.)

While children progress at different rates and at different absolute ages, the progression will occur in the same order for all. Movement from one stage to the next is driven by an accumulation of errors or mismatches between the way the child thinks about the world and how (s)he experiences reality. A child cannot skip steps. Logical reasoning (which develops in the concrete operational period) must be present for abstract reasoning (formal operational period) to appear. For this reason, Piaget maintained that what a child can learn will depend on his or her stage of cognitive development. Learning, then, necessarily lags development. (In contrast, Dewey might say that learning *drives* growth. (Archambault,1964))

Lev Vygotsky, who lived in the Stalinist Soviet Union, argued that development is more than a biological process. Rather, social relationship, too, is important to the development of psychological processes (Műller, 2008, p 184). Thus, learning is not "simply" determined by biological development, but also by the larger social environment. The teacher should guide students' interests toward culturally determined goals. In this way, the teacher, as a representative of society, mentors the student toward ever more complex cognitive awareness. (Glassman, 2001, p5) (In contrast, Dewey suggested that a student, naturally immersed in everyday activity will come to focus on an area of intense interest – to the student, not necessarily to the teacher. It is the teacher's role to facilitate this interest. (Glassman, 2001, p4)).

Piaget also felt that social interaction is important to development. He showed that a relationship could be *symmetrical* (in which the participants have equal power) or *asymmetrical* (in which one party has power over the other). Vygotsky's classroom, led by a mentor/teacher is an example of the learning in an asymmetrical relationship. In contrast, cooperative learning groups in which students learn with and from each other would be a symmetrical arrangement. In the former case, the student understands that rules delivered by the authority figure are to be taken intact, while the latter case presents a method or *process* by which equilibration might occur or by which 'original action' can be superimposed upon pre-formed constructions (Műller, 2009, p.280).[2] In *Sagesse et illusions de la philosophie*, Piaget said:

> We see that the child, different from the adult and often different at school, creates a *social life with his peers*; and especially we notice that , in measure to the degree to which he mixes with his peers, he reaches, intellectually speaking, both a critical spirit and a sense of reflection. … Yet, why is this *tendency towards cooperation* that we observe in children more likely to be crushed rather than used and developed by education? [original emphasis] (Piaget, 1965)

In the current study, this tendency will be apparent. It will also be of interest to note the asymmetric relationships in Sailplane and to consider the roles of both in the students' learning.

Based on research in the 1950s and 1960s, William Perry took an important step when he extended the stages of development that Piaget had postulated to include college-aged young adults. Perry (and others) proposed a series of nine "positions" that described the intellectual development of college students. From Piaget, Perry used the

[2] Note: The discussion from which this is taken addresses moral development, not the understanding of physical reality. The argument that I am making here is that the *process* for developing understanding of the aerospace engineering seems to me to be similar. This supposition should be tested rigorously.

dynamics of ‘accommodation’ and ‘assimilation’ to describe the dynamics of growth from one position to the next. When a student encounters a problem resolving real-world experience with his/her theoretical understanding of the world, the student is forced to change or expand his/her cognitive understanding to include the ‘new’ experience. This work has been influential in directing the subsequent theory of education in the university. The stage of development of a student heavily influences how they learn. Similarly, the education itself helps the person to move from one stage to the next by presenting appropriate challenges to their thinking. Perry’s positions (as amended in 1981) can be summarized as follows:

> Position 1: Basic dualism – Authorities possess the one right or good answer. Truth is absolute.
> Positions 2-4: Multiplicity – The recognition that even authorities can disagree, leads students to accommodate a variety of truths.
> Position 5: Relativism – Complexity is expected. All knowledge and values are relative and contextual. In the absence of authority, any opinion is as good as any other.
> Positions 6-9: Commitment to relativism – The student struggles to avoid the catatonia of infinite possibility by ‘committing’ or defining him-/herself through personal choices (commitment) and allegiance to values that have personal meaning. Thus, ethical development is seen to follow intellectual development.
> (Love, 1999)

Perry’s formulation has been important because it provided a framework for research on epistological development. Subsequent research has led to refinement of Perry’s positions, extending them to a more diverse population than was included in Perry’s original research. (Love, 1999, p.13) (Interestingly, a semi-structured interview formed the basis of Perry’s research method. (Love, 1999, p.6))

About the same time that Perry was proposing his “positions” of cognitive and intellectual development, Arthur Chickering proposed a set of seven “vectors” along which students move in developing identity during the college experience. (The synopsis presented here follows the discussion in Pascarella and Terenzini (1991), pp 20 – 23.) Chickering called them vectors as they seem to have magnitude and direction. The seven are:

1. *Achieving competence*. In college, students develop a sense of competence in intellectual areas, manual skills and interpersonal relations.
2. *Managing emotions.* During this period of life, a person must deal with intense emotions of both biological and social origin. Value systems inculcated by parents and childhood experience are examined and eventually adapted to an internally motivated set of behavioral standards.
3. *Developing autonomy*. Chickering states: "[Autonomy is] the independence of maturity. … It requires both emotional and instrumental independence and recognition of one's interdependence." (cited in Pascarella, (1991) p. 21)
4. *Establishing identity.* A sense of self is the result of growth along the first three vectors and facilitates the growth along the subsequent three vectors.
5. *Freeing interpersonal relationships.* The ability to interact with others (including tolerance and respect for diverse opinions and values) and to develop intimacy with close friends depends on a strong personal identity.
6. *Developing purpose.* Expanding competencies, identity and personal relationships provide the basis for prioritizing professional interests, vocational plans, aspirations and life-style choices.
7. *Developing integrity.* This refers to "the clarification of a personally valid set of beliefs that have some internal consistency and that provide at least a tentative guide for behavior."

A thorough discussion of Chickering's theory is beyond the scope of this paper. Still, in regard to the current study, it is relevant to note that:

1. Growth along the vectors is not simply maturation, but requires stimulation (Pascarella, 1991, p. 22);
2. The university environment influences growth (that is, augments and retards growth) along the seven vectors. Some of these influences are seen to exist in Sailplane, including "friendly contact with faculty in diverse settings" and the "friends, groups and student culture" encountered there (Pascarella, 1991, p. 23)
3. The Sailplane class provides the conditions for growth along several of Chickering's vectors, including vector 1 (achieving competence), vector 3 (developing autonomy), vector 4 (establishing identity), vector 5 (freeing interpersonal relationships) and 6 (developing purpose).

A deeper study of the extent to which the environment in the Sailplane class provides conditions of growth described in Chickering's vectors would be of interest.

"Grounded Theory" and research methods developed in the social sciences

Higher education in the middle of the 20th century had changed little from the "classical model" that was dominant when Dewey began his career at the turn of the 20th century. (Lapp, 1975, pp 21-37, 82). The normative practice was still a series of distinct course "units" presenting a sequence of topics seen by the professors to be "fundamental knowledge". Students were passive recipients of this stream of wisdom. But the store of fundamental topics never got smaller; it only got bigger as fields of study from Physics to Computer Engineering exploded in new directions. Time did not suffice to teach all the heritage subject matter *and* the new essential knowledge that young students would need to succeed in the years ahead. Knowledge so laboriously gained by students became obsolete in a matter of a few years. "The fundamentals", once seen as the foundation for a lifetime career now had to be viewed as stepping stones to perhaps a completely different set of fundamentals as the course of knowledge moved inexorably and ever more quickly forward. A student could no longer view college training as sufficient for a sustained career. Rather, continuing education and intellectual growth came to be regarded as ongoing processes throughout the student's adult life. This continuous process of self-education is sustained with only the occasional help of professors and classrooms. The view of learning as a life-long process contributed to the view that the engineering environment is a learning environment and is an appropriate place for engineering education to take place.

In this way, Dewey's view of "connected" or experiential learning and the new theories of the stages of development informed a new vision of what education should be in order for engineers to be equipped for success in the fast-evolving developments of the information age. What remained was to link those theories to educational practice and to scientifically establish their value for increasing learning. Theorists, such as Dewey customarily demonstrated their theories in experimental schools that showcased their methods. What was needed, however, was a comprehensive record of research into the new practices that would establish effectiveness in meeting the goals put forward by the theory. The methods of "Grounded Theory" first articulated by Glaser and Strauss provided a way to supply such evidence.

The goals of the new education (to impart, for instance, expert behaviors, good judgment and adaptive skill under novel conditions) are difficult to observe, much less to quantify. Dewey himself described the problem in this way:

> That which can be measured is the specific…that which can be isolated…[But] how far is education a matter of forming specific skills and acquiring special bodies of information which are capable of isolated treatment?...The *educational* issue is what *other* things in the way of desires, tastes, aversions, abilities and disabilities is [the student] learning along with the specific acquisitions? [Cited in McCarthy, (1998) p115. Emphases in the original.]

Grounded theory provides a way to evaluate the new approaches against the varied claims of their proponents. Using techniques from social science research, in particular ethnology, grounded theory calls for gathering data in a number of forms and from a number of sources and using induction to isolate patterns of behavior. These patterns, or categories, are tested for typicality and extent and become the basis for further theories ('grounded' in data) that can in turn be evaluated. In this way, the affective and environmental conditions that Dewey referred to as having a bearing on learning enter into the analysis, not just subject matter test scores. Haig (1995) explains it this way:

> Grounded theory is regarded by Glaser and Strauss as a general theory of scientific method concerned with the generation, elaboration, and validation of social science theory. For them, grounded theory research should meet the accepted canons for doing good science (consistency, reproducibility, generalizability, etc.), although these methodological notions are not to be understood in a positivist sense. The general goal of grounded theory research is to construct theories in order to understand phenomena. A good grounded theory is one that is 1) inductively derived from data, 2) subjected to theoretical elaboration, and 3) judged adequate to its domain with respect to a number of evaluative criteria. Although it has been developed and principally used within the field of sociology, grounded theory can be, and has been, successfully employed by people in a variety of different disciplines. (Haig, 1995, p 1)

How People Learn **(Bransford, et al., 2000)**

Research on learning, (in light of the theories of cognitive development and educational theories that emerged in the first half of the 20th century) underwent sustained effort, beginning in the 1960s. Pascarella and Terenzini in their mega-study entitled, "How College Works" published in 1991, reviewed hundreds of studies that had been conducted from 1967 to 1989. In 2000, Bransford, et al first published a report (*How People Learn*) [HPL] of a 2-year study by two commissions of the National Research Council to implement the research of the past decades into a theory of learning that would have practical application in new approaches to teaching. The titles of the two committees, (Committee on Developments in the Science of Learning; Committee on

Learning Research and Educational Practice) indicate how the objective of this effort was to synthesize the research into a science of learning and thus to an improved practice of education.

In HPL, the authors investigate differences between ‘novice’ or ‘amateur’ behaviors and ‘expert’ ones in regard to processing information and solving problems. They imply that “learning” relates to a student’s attempt to gain an understanding of the world around him/her. The inclusion here of ‘understanding’ as a defining characteristic of learning is key to this approach as it separates that which is known ‘intuitively’ (and thus is unexamined, but also is untaught) from that which is learned. “Learning is important because no one is born with the ability to function competently as an adult in society,” they state (Bransford, et al, 2000, p.51).

Another key element of their study is “transfer”. Transfer refers to two very different things: How knowledge is generalized (that is, how knowledge is applied to a novel situation, a defining characteristic of expert behavior) and the study of effective teaching. Their study of a science of learning, therefore, leads them to consider effective teaching techniques and learning environments. In this regard, the authors are firm advocates of active learning, in which students take control of their own learning (Bransford,et al., 2000, p.12). Active learning requires the “metacognition” that is seen to be a characteristic of expert behavior. Metacognition is “the ability to monitor one’s current level of understanding and decide when it is not adequate.” (Bransford,et al., 2000, p. 47). It is seen as a differentiating characteristic of expert behaviors from novice behaviors (Bransford,et al., 2000, p.50) because experts will step back from their initial naïve approach to a problem to consider alternative models and approaches.

Metacognition also motivates ongoing education, because it reinforces the habit of assessing the limits of one's knowledge and the skills to acquire new knowledge in a timely manner. "Students become more aware of themselves as learners." (Bransford,et al., 2000, p. 67) and metacognition encourages learning with understanding (Bransford,et al., 2000, p. 59). "Metacognitive approaches to instruction have been shown to increase the degree to which students will transfer to new situations without the need for explicit prompting." (Bransford,et al., 2000, p. 67). Thus, metacognition should be an element of active learning and the transfer that requires students to solicit feedback and to actively choose appropriate strategies for the solution of a technical problem (Bransford,et al., 2000, p. 66). We will look for evidence of metacognition in the language and attitudes of the Sailplane students.

The HPL study concludes with three implications for teaching:

1. Teachers must work with the students' pre-existing understanding of the subject matter.
2. Teachers must teach some subject matter in depth, providing a firm foundation of factual knowledge.
3. The teaching of metacognitive skills should be integrated into the curriculum. (Bransford,et al., 2000, pp 19 – 21)

In my previous work (Wheeler, 2003), we found scant evidence that the first of these practice was present in Sailplane. Rather, incoming freshmen are assumed to have no prior knowledge of aerospace engineering. The second item is indeed a fundamental tenet of the program: whoever teaches the class is expected to have a deep understanding of the fundamental principles of sailplanes (Maughmer, private correspondence). A student in the class comes to see him- or herself on a continuum from naive incoming student with no inkling of the concepts of the aerospace engineering to the instructor, who is regarded as an unquestioned authority. Thus, the relationships within the class are ‘symmetric’ or ‘asymmetric’ (as defined by Piaget) and a student’s position in the class is defined by his/her knowledge of these aerospace-specific concepts. In our study of relationships that students form during their time in Sailplane, we will look for evidence for this orientation.

In this chapter, a framework is provided for understanding the practices of the Sailplane class that are rooted in theories of education (Dewey) and intellectual development (Piaget, Perry, Chickering). I also provide a conceptual framework for the manner of going about the study. The advent of grounded theory provides a basis for the qualitative approach to asking questions related to invisible student behaviors. Finally, a particular study, How people learn (Bransford,et al., 2000) is cited as an example of how a conceptual framework can be applied to justify recommendations for the improvement of teaching practice. In a similar way, this conceptual framework gives us a structure for our study of Sailplane. The methods of this study, focusing on the student voice, are well suited to investigating these issues.

Chapter 3 Methodology

Why Qualitative methods?

A class like Sailplane has many pedagogic objectives. In such experiential classes, no one numerical metric will provide insight into the quality of the experience and its implications for the learning of aerospace engineering precepts. In this study, the quality of the experience is a central focus. I am curious how the quality of experience relates to the learning process and to other positive outcomes that Sailplane seems to produce for the Penn State Department of Aerospace Engineering, such as 'commitment to major'. To quote Patton (2002),

> Qualitative methods are often used in evaluations because they tell the *program's story* by capturing and communicating the *participant's stories*. [original emphasis]. (Patton, 2002, p10)

This is indeed the task at hand: To record the broad story of the value of the Sailplane class through participants' stories. Based on this evidence, I intend to make inductive judgments as to the factors that contribute to the positive outcomes we observe. An advantage of the singular nature of the case (and its physical proximity) was that I had easy access to the setting and to those who were involved in it. According to Bogdan and Biklen (2003), naturalistic (that is *in situ*) sources of data, descriptive data, a concern with process, inductive analysis, and participant perspectives of meaning are the five foundational attributes of qualitative research in educational settings (Bogdan (2003), pp 4-7). The following quote from Strauss and Corbin could be seen to apply to this parochial context just as in those authors' grand argument for the application of qualitative methods:

> [Qualitative research refers] to research about persons' lives, lived experiences, behaviors, emotions and feelings as well as about organizational functioning, social movements, cultural phenomena and interactions between nations. (Strauss, 1998, p. 11).

Quantitative methods would not be appropriate in the current context, since the number of students available as respondents is small. It would be difficult to control for factors that might distort the statistics, such as background experience or parental affects. A broad general sample is impossible. Sailplane is an elective honors course, so the participants are already self-selected and highly motivated. Sailplane, as is typical for a project-based course, is highly distinctive and particular to its context in the College of Engineering at the Penn State University. So comparison with other PBCs in other departments, colleges and institutions is difficult. Since we are interested in the processes of learning and since the issues of concern for teachers and curriculum designers are broad, they resist formulation into rigid hypotheses that lend themselves to quantitative test. Perhaps an outcome of this study will be to identify questions that *would* lend themselves to quantitative investigation.

Our study is a first attempt to investigate PBCs at the Pennsylvania State University College of Engineering. We are interested in undertaking this evaluation in order to make a case for the effectiveness of PBCs in this context. Since there are a limited number of PBCs at Penn State (and the author is involved in some of them), our study will effectively be a case study. A case study, as defined by Merriam (1998), is "an intensive, holistic description and analysis of a single instance, phenomenon, or social unit". She argues,

> The case study offers a means of investigating complex social units … Anchored in real-life situations, the case study results in a rich and holistic account of a phenomenon. It offers insights ... that help structure future research; hence, case study plays an important role in advancing a field's knowledge base. … Case study has proven particularly useful for studying educational innovations, for evaluating programs, and for informing policy. (Merriam,1998, p 41).

These goals (along with improvement of the Sailplane class itself) are indeed our goals in undertaking this study. Our purpose is to look minutely at the program 15 years after its inception and to draw conclusions about its effectiveness with respect to teaching and learning goals that are ascribed to PBCs. A case study can be viewed as comprised of nested, layered, overlapping layers of inquiry (Patton, 2002). For instance, this case study of Sailplane could be seen as the amalgamation of many interviews, each one a mini-study of a student's experience. Likewise, it is hoped that ultimately this study will form a part of a larger body of knowledge relating to PBCs in various environments that collectively would argue for the effectiveness of this method of teaching.

While case study is appropriate for developing rich description of a particular instance, it is important to emphasize that it alone does not lend itself to generalization. What we learn about Sailplane may not apply to other PBCs. It will be up to the reader to determine how our findings might apply in other circumstances. In other words, it will be up to the reader to decide if the findings of our study are 'typical' of PBCs or 'unusual' (Bogdan, 2003, p60). Both coexist in a study of an innovative program such as Sailplane.

Patton (2002) warns that case study is particularly vulnerable to researcher bias. He notes that there are many steps in the design and execution of the case study, as well as in the analysis of the data, that will require judgment on the part of the researcher in order for the study to remain on target with the research goals. This is certainly true in the current instance as my interest in PBCs is at the heart of my interest in this study. This argument is often brought up in relation to the reliability of qualitative versus quantitative studies. The answer is to first recognize that no study can be entirely free of the influence of the researcher's expertise. Furthermore, that expertise is valuable for providing a vision and direction to the work. Nevertheless, care must be taken that the conclusions of this or any study follow from the respondents' data, not the researcher's particular notions of what is important. I will address this by making evident the bases of my decisions. In that way, neutral observers can benefit from this work, but also can follow my decision-making process and judge for themselves if the conclusions are firmly based in the data.

In the current instance, case study allows me to approach the question of the value of PBCs from a unique perspective – that of the participants themselves. I hope that my findings will convey the excitement that these students find in working on a full-scale sailplane. I expect that the storyline that emerges will include both elements of passion and also perhaps some of the naiveté with which these students naturally approach their impending careers.

The basis of the study is a series of semi-structured interviews, in which I sought to form a 'research partnership' with the Sailplane students. In this, I lean heavily on the arguments of Mishler (1986), who proposes that interviews are 'speech events', not stimulus/response experiments. He cites the importance of the context of the interview, the language of the questions and answers, the empowerment of the respondent in a trusting relationship between interviewer and respondent as factors for a successful interview (Mishler,1986, pp21-24). Done well, an interview yields details of the respondent's day-to-day experience. The interviewer and the respondent work together to understand an event within the context that gives the event meaning. This context is at least in part created by the respondent. Therefore, if we are to understand how learning occurs in the Sailplane Project, it is important to let those involved in the process be the source of the data that will support our understanding. Seidman (1998) expressed the same view this way: "At the root of in-depth interviewing is an interest in understanding the experience of other people and the meaning they make of that experience (Seidman, 1998, p3). My interest in the workings of Sailplane was met by an eagerness on the part of the Sailplane students to contribute to this research, which they perceived would benefit Sailplane. In my view, this trust was the basis of the high degree of cooperation on the part of students and faculty involved in Sailplane.

To my knowledge, most respondents did not know much about me. From my initial introduction to the class, they knew that I was director of the SPIRIT program. One respondent was a part of both classes. Thus, it was evident to at least some of the participants that I was familiar with programs of this type. On the other hand, only three respondents alluded to SPIRIT – and some, it was clear, had not heard of it. Therefore, I conclude that my position in SPIRIT was not a big factor in their participation, nor did it color their responses.

In the interviews, I sought to place them in the position of the expert. I assumed the stance of a curious newcomer. When asked, I told them that Sailplane was the focus of my masters (Education, not Engineering) research and these interviews were part of my effort to discover detail about the Sailplane program. I emphasized that I was interested in their individual experiences. It would be through the accumulation of such experiences that I would endeavor to construct a holistic portrait of the program as it was then. I asked, for example, not "Describe what happens in the first class of the semester", but rather, "Describe your impression when you walked into the class on your first day."

I chose semi-structured interviews as the most appropriate instrument for this inquiry. By 'semi-structured' is meant that an extensive interview protocol was developed (see Appendix A), but I felt free to shuffle the order of the questions and to seek further detail when a line of questioning seemed promising. It also allowed me to dwell on an issue until I was confident that I understood the main points and that I had the emphasis right. In re-reading the transcripts, I must admit that sometimes the student had to say something two or three times before I finally understood that it was important to them!

It was intended that the structure would provide focus to the interviews and would allow comparisons across dimensions such as age. On the other hand, I sought a 'comfortable' setting where respondents would feel free to expand their answers, relate stories, or suggest whole lines of experience that they felt important for a nuanced understanding of how and what kind of learning takes place in the Sailplane Project.

Structured interviews depend on an asymmetrical balance of power. For example, medical interviews (between doctor and patient) are typically directed by the doctor for some definite purpose (filling out a form, progressing from a set of symptoms to a prognosis). The questions have a definite purpose and the responses need only be 'good enough' to accomplish the purpose. The respondent soon learns how to construct such an answer and to provide no more information than necessary (Mishler 1986, p. 54). Thus, the structured interview was not a suitable instrument for our purpose.

Semi-structured interviews, by contrast, exist within theoretical boundaries (the protocol), but proceed in an even-handed manner. Interviewer and respondent work together – either can direct the question/response to areas of important meaning. The questions are written, but they may be re-worded in the asking in order to better convey the sense of the query. Mishler (1986) points out that from one interview to another, it is more important that the meaning of the question be consistent than the wording (Mishler 1986, p. 22). The respondent is then given as much time as necessary to express an answer. Context, timing, grammar, manner of expression are all tools that a respondent should feel free to develop in the course of his/her response.

Quite often, a response is expressed not as an answer, but as a story. Stories are a common method for connecting meaning and speech (Mishler, 1986, p. 75). It is a technique that is deeply ingrained in the human psyche (Rayfield, 1972, cited in Mishler, 1986, p. 67). Stories allow the teller to generalize a personal experience. They can be used to relate ambiguous events. (That is, rules of narration can be used to relate an event even if the moral is not yet clear.) Stories can also be compared between respondents who shared an experience. Stories are also useful for the researcher because techniques of narrative analysis can be applied to the interview results.

So, the goals of this study (recording the student experience of Sailplane in their own voice) are enhanced through the telling of stories. The strength of semi-structured interviews is that they enlist both interviewer and interviewee in constructing meaning and they encourage the telling of stories.

The interview protocol was used primarily as a guide to constrain the conversations to topic areas important to the research question. Before each interview ended, I would scan the protocol to make sure that important areas had been covered. The protocol was also useful as a crutch when I felt that I was not fully following the meaning being expressed. Luckily, this occurrence was rare, but when it did occur, I could read the questions directly from the protocol. Otherwise, I felt free to cover the topics in whatever order seemed to be 'natural' in a particular interview setting.

I have identified five ways to categorize Sailplane experiences. The categories included Expectation, Socialization into the community, Transforming experiences, Evidence for growth and Outcomes. (Please see Figure, 3-1) These categories became the basic structure of the interview protocol and of the post-interview open coding hierarchy.

It was not expected that Sailplane students would progress through these areas in sequential fashion. Rather, I felt that by capturing the student experience in these five

Areas, I could piece together a comprehensive picture of the total Sailplane experience. These areas do not constitute "stages" of experience in Sailplane. Rather, they are categories of experience. These categories are only temporal in that, for example, a new recruit would not be expected to have had a transforming experience. The objective of the interviews was to capture the stories of the respondents in rich detail in these five areas and in such a way as to

Table 3-1: Categories of experience in the Sailplane class.

These categories formed the structure of the interview protocol and of the initial open coding scheme. Please refer to the Coding Inventory to see examples of responses in each of these areas.

Expectation	Forward-looking experiences include the expectation of a student for what lies ahead. This includes what a young student expects to happen because of his/her participation in Sailplane and it includes what an older student expects to happen because of his/her participation in Sailplane.
Socialization into the community	This category explores the stages through which a new student is accepted (or not) into the very strong community structure of Sailplane. Stories of both the social environment (and its relation to learning) and of dimensions of community in Sailplane are captured here.
Evidence for growth	I expect that there would be evidence for growth along several dimensions. Professional growth and personality development, for example, would be evident in the difference between a freshmen's experience and that of a senior. (No argument for causation is implied.)
Transforming Experiences	It is expected that growth is not linear. Rather, periods of consistent work and slow progress are followed by intense experiences that are followed by leaps in cognitive and personality growth. Intense, transformational experiences are expected to be markers of such growth spurts.
Outcomes	What outcomes do students cite after their long hours of work in the Sailplane course? How do these outcomes affect their prospects? What value do they ascribe to them? Do they distinguish Sailplane students from those who did not take the class?

Categories of experience in the Sailplane class

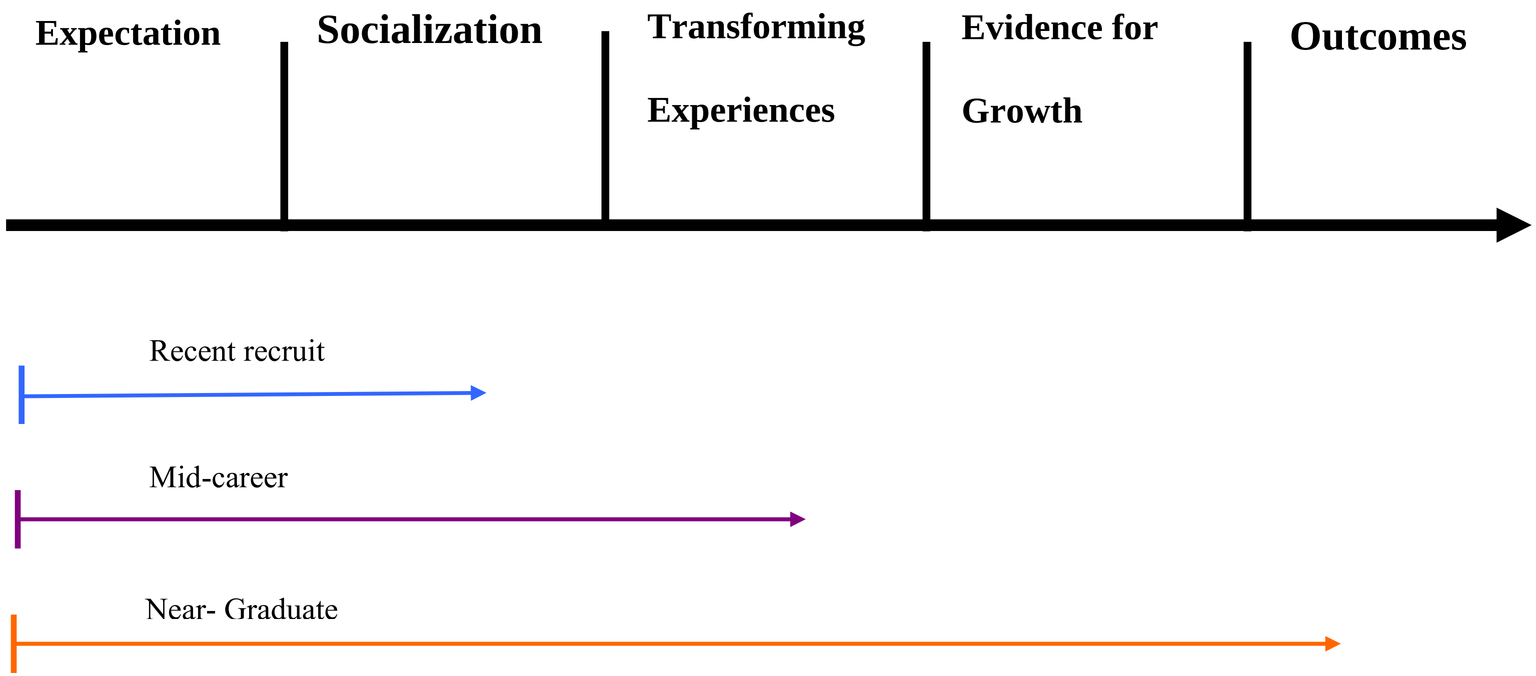

Figure 3-1: Categories of experience that formed the basis of the interviewing protocol.

The figure indicates that a recent recruit would be expected to have had "socialization experiences", but not "transforming experiences".

understand their experience in its wholeness. The challenge of eliciting a holistic view of a particular student's Sailplane experience then became the challenge of constructing an interview protocol that would draw out the student's experience of each of these categories of experience. During later coding, the purpose of these 'bins' was to organize the rich detail in a way that could be compared, grouped and/or analyzed among the various stories in order that patterns or trends might be noted. These patterns and trends will comprise the outcome of this study and the raw material for further work.

In formulating the questions, I benefited greatly from the work of Dana, et al (2003) who presented guidelines for how to formulate questions to elicit expansive responses. I am also indebted to Seidman (1998) for his presentation of a practical method for administering a program of semi-structured interviews.

Research Question

Formally stated, the research question for this study is:

> From a student participant perspective, what is the value of the Sailplane experience? What is the function of the class in that student's education and development? In a general sense, what domain-specific knowledge do they acquire? In this collaborative environment, how do the students know that what they are learning is right?

For each of these questions, we focus on the perspective of those involved in the program and ask: What do they expect to get? What do they actually get? And, what do they do with the experience?

Synopsis of methods

Per IRB guidelines, the conduct of the interviews included the following steps: Before the semester began, I conducted a practice interview with a SPIRIT student and two Sailplane interviews with people that Pipa recommended as being ‘model’ students. (Informed consent forms were administered individually in these cases. The SPIRIT student interview is a ‘practice’ interview, used for confirmation only.)

In the second week of class, I stood before the class and gave a general explanation of the project. At that time, I asked the class members to fill out an informed consent form and a demographic survey. Those who did not want to participate in the study were to return the forms without filling them in. 100% of the class gave permission.

The demographic survey became an independent information source and was helpful in guiding sampling throughout the semester (See Table 3-2 below). I began by picking students to form a comprehensive, but shallow, coverage of the various dimensions of the class. Those dimensions included:

Academic year
Experience with sailplanes
Gender
Semesters in the program

I then concentrated on getting interviews from a sampling of those who would graduate in December. Several people who had been in the program for eight or nine semesters were graduating in December and they were could provide a comprehensive view of how the program has evolved. Of course, they were also in the position to give me a view of their student ‘career’ in Sailplane in its entirety. I felt it important to get their stories. For each of the other class levels, the data provided two elements: A selective view of the importance of the preceding years as it led up to the present; and a check on the recollections of the older students. In other words, when interviewing a junior, I am both asking about what the junior experience is like in light of the freshman, sophomore experiences AND I am checking the seniors' recollection of what it was like to be a junior in the program.

Having completed the broad coverage and having interviewed several of the December graduates, I tried to talk to students who might define the bounds of the group experience. This group included:

- A student who, judging by his clothes and by his behavior, looked to be an individualist. This student had just come from a branch campus and had joined Sailplane as a junior.
- A student who had quit the program a year or so before
- A student in his first semester as a graduate student who was close enough to the program to provide a complete view, but already felt a distance between himself and the current participants
- A graduate of the program in its early days who now hires Sailplane students as interns
- In addition, one freshman, who had consented to talk to us in the first weeks of his participation in the class agreed to return for a follow-up at the end of the semester.

Table 3-2: Demographic data for 17 respondents.

P1 was a practice interview, not used in the analysis. S01 – S08 constitute a survey of these demographic dimensions. S09 – S16 were selected for reasons indicated in the 'comment', or to strengthen the survey

Respondent	Gender	Graduation	Semesters in Sailplane	Comment (source of contact)
P1	M	May 07	5	Practice interview with a SPIRIT student (TFW)
S01	M	May 06	4	Physics major; has built an airplane (Pipa)
S02	M	May06	5	Well-regarded leader (Pipa)
S03	M	May08	3	Sophomore; (approached in class)
S04	F	May08	3	Interviewer:Honwad; S04 was also part of SPIRIT (TFW)
S05	M	May09	1	New recruit (2 weeks); re-interviewed in Dec. by Honwad (Demographic data)
S06	F	May07	5	Well-spoken junior (Demographic data)
S07	M	May06		Joined as a freshman, then left (Pipa)
S08	F	Dec05	8	One of super seniors soon to leave (Demographic data)
S09	M	May05	8	Super senior (Demographic Data)
S10	M	Dec05	8	Super senior; one of 2 stdt lab T/As (Demographic data)
S11	F	Dec05	7	Super senior; (Demographic Data)
S12	M	May07	1	New transfer from branch campus; many markers of a non-conformist (approached in class)
S13	M	May09	1	New freshman, interviewed in Nov (Demographic data)

S14	M	Aug05	7	Recent grad, now a MS stdt in Aero (Pipa)
S15	M	May1992	4	Transfer from Altoona; offers perspective from very early in class history; still tangentially involved with class; hires Sailplane interns; has his own sailplane (Pipa)
S16	M	May2009	1	Self-assured in lab, one would not guess this person was a freshman! (Demo data)
F17	M	N/A	0	George Lesieutre, Dept of Aerospace Engineering Head (in 2007, when interviewed) (TFW)

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I had some familiarity of how Sailplane is structured and of the philosophical underpinning of the course from a preliminary study (Wheeler, 2003). That work was useful during the design of the current study. It was in that study that the five areas of inquiry were discovered. It was during that work that I interviewed Dr. Maughmer, Pipa and two students. This data is used for corroboration only since they were taken outside the IRB permissions for this study.

In practice, I found that the best interviews did not proceed methodically from one category to the next. Rather, the conversation would jump around from area to area in accordance with the interests of the respondent. By the fourth or fifth interview, I was familiar enough with the protocol to be able to go along with the flow of the discourse while keeping the overall structure in my head. This allowed the topics of particular concern to remain central to the interview. It was left to the open coding step to untangle the threads of the different interviews. For example, one student had earned a B in the course one semester. This was a low grade, indicating minimal effort. He felt the low grade was unjustified. Despite this slap in the face, he had persisted with the project and had continued to make (by his measure) enormous technical contributions. During the interview, we did cover all the categories, but the flow of the discussion repeatedly circled back to this one event that was central to his Sailplane experience.

The effort required to mentally keep track of the structure of the interview while responding appropriately to the discourse was only possible because the interviews were recorded. I made written observations before and after the interview, but during the event, I focused on the oral exchange. In one instance, a student asked that I turn off the recorder in order to give me an account of a transformational event. Otherwise, the small tape recorder, prominently placed on the table did not seem to inhibit discussion.

The interviews were strictly limited to ninety minutes. This length of time suggested by Seidman (1998) was a comfortable limit for my own endurance. Three of the interviews only lasted an hour. Every respondent appeared for the interview in a timely manner. This I took to be indicative of their eagerness to participate in the study.

With three exceptions, the interviews took place in a small conference room near my office in Electrical Engineering East. This internal conference room has no windows and is constructed of painted concrete block. There are two entrances to this room, which had to be closed so that hallway noise would not disrupt the recording. When these doors close, there is a palpable sense of isolation in the room. The ventilation is insufficient, so the air gets progressively close. The room is well-lit and has a single round table, a blackboard and an excess of chairs. A single row of perhaps two dozen photographs of young to mid-career engineering professors rings the room. These black and white photos are of uncertain age and add a collegial atmosphere. Two large, colorful posters related to space vehicles complete the architectural features.

On several occasions, we had to move from this conference room in the middle of the interview to accommodate previously scheduled meetings. In those cases, we moved to an outer reception area attached to my office. This room is common to two offices and was originally designed for support staff. It is even smaller than the conference room, rectangular and dark. There is a table with a few chairs and some clutter related to a coat rack and file cabinets. Conversation from the secretary's office next door can be intrusive. There was occasional traffic through the room which was also distracting. The interview seldom lasted long after we moved into this room. Its dark, cluttered ambiance, along with the distractions, seemed to tax interviewer and interviewee alike. Both of these settings, distant from Sailplane labs and classrooms, were unfamiliar to the students and were intended to provide a sense of distance from Sailplane activities. I hoped that they would report to me about Sailplane, rather than display their Sailplane 'persona'. With one notable exception, the students seemed comfortable in the unfamiliar setting. S16 was visibly nervous at the beginning and end of the interview and once in the middle when he was apparently bored with the proceedings. I judged that this was a social discomfort, rather than a result of the surroundings. Perhaps I was controlling the conversation too much and not letting him guide the interview to topics of interest to him.

Most of the interviews took place in the early afternoon on a day negotiated by email. In two cases, the respondent had a commitment directly following the interview. Otherwise, they seemed to be willing to talk with me until I terminated the interview. All expressed a willingness to return if further questioning was necessary.

During the data-taking period, Pipa served as an excellent key informant. He was thoroughly knowledgeable about sailplanes and all aspects of the course. He was able to put me in contact with current and former students whenever I asked for the name of a person of a particular profile. He could explain the features of the course and why they had been adopted. His efforts were key to the success of this endeavor.

Having recorded the interviews, I transcribed each one into an .rtf file using a transcription pedal and WavPedal software. I attempted to render a verbatim transcription that included mis-starts and indicated tone, simultaneous utterances and sounds/phrases of encouragement as they occurred. In Appendix B, I have included a list of the transcribing conventions that I used. These conventions are my own, so there is some inconsistency from the first transcript to the last. A sample section of a transcript is also included in the appendix to demonstrate the use of these conventions.

Data analysis methods

The data sources for this study consist of

- Seventeen interviews with Sailplane students, including two ‘practice’ interviews. A separate protocol was used for the 17th interview with Dr. George Lesieutre, Department of Aerospace Engineering Head. (See Appendix C)
- A preliminary study, entitled “Sailplane assessment results” completed as classwork (Wheeler, 2003)
- Comments from SRTEs from 2001.
- Conversations with Pipa, Dave Maniaci (T/A), and Joel Peltier (who had recently hired Sailplane students). These conversations were not recorded and since the respondents are not students, they are not part of the central body of data. They are very useful, however, for checking my understanding and perceptions and thus reducing researcher bias.
- 47 Memos on various aspects of the data-taking process. They include researcher observations at the time of the interviews, researcher thoughts and speculation for later comparison with interview data, and methodology notes.
- Two published papers discussing the philosophy and origins of the Sailplane concept

- Another study, (Marra, et al, 2001) was useful in designing the current research program.

For the coding steps, I came to appreciate the NVivo program, authored by qualitative researchers. This full-featured program made the organization and open coding steps much easier. I established a hierarchy of codes that reflected the five stages of Sailplane experience that I wanted to examine (Expectation, Socialization, Transforming experiences, Evidence for growth and Outcomes) per Table 3-1 that I had used in constructing the interview protocol. As I studied the transcripts, in vivo codes were added to fill in these categories or to highlight topics of importance to the interviewees that emerged from our discussion. Having performed a thorough open coding of the interview transcripts, I consolidated and re-organized the code list to highlight areas that came up most often. Please see Appendix D for a complete list of 100 codes, along with an explanation and example of each.

I then sorted the data to reveal 'typical' behavior, to explore the range of experiences cited. The Storyline Narrative chapter which follows is the result of the 'typical' experiences of freshmen, sophomores, juniors, seniors and post-graduates. I then constructed a list of topics for further study, based on frequency of occurrence in the interviews, the level of importance of the issue to the respondents, or my perception of themes that appeared in a wide cross-section of the interviews. In these areas, the codes were analyzed again. I checked the context of the coded segments in the transcript to make sure that my conclusions were true to the originally expressed meaning I could then re-check the major conclusions with Dr. Maughmer and other faculty for their feedback

Limitations of the data-taking methodology

The primary weakness of the data-gathering method was that it was performed by one person alone. This is particularly serious in light of Patton's remark (cited above) suggesting that case studies are sensitive to researcher bias. Time did not suffice to return to selected respondents to check that I understood their points and to ask for confirmation of the conclusions.

After the data-taking period, I felt that my method had produced a comprehensive snapshot of the Sailplane class at this pivotal moment in its development. There were several areas where more data might have been collected. For instance, the social dimension of the project is clearly fundamental to its effectiveness. I observed a total of one class and three lab periods. It is possible that a series of regular visits throughout the semester might have allowed me to observe the interactions systematically as the relationships matured over the semester. I never felt that my presence was having an effect on the proceedings. (I confirmed this with a TA whom I knew well and who I was confident would give me an honest answer.) On the other hand, I judged my skills as an interviewer to be better than my skill as an ethnologist. Repeated interaction with the subjects would have had an impact on the tone of familiarity during the interviews. (I believed that since I did not know the respondents and they did not know me well, that I would get a more objective answer.) It was useful to question the students with an outsider's perspective. Nevertheless, my understanding of the all-important social environment is dependent on the reports of the participants, not on direct observation. If there had been more researchers involved in the project, this is one area where expanded observation might have been useful.

In addition to the interviews gathered here, a focus group discussion would have been fascinating. The students clearly valued each other's opinions and I am sure a lively discussion would have stimulated insights that individual respondents might not have seen as important. In the current case, I did not feel that a focus group was possible since it would have reduced the pool of interviewees dangerously. Again, it would have required a different personality to serve as moderator.

My attempts to mitigate these weaknesses included the following:

1. I checked facts and perceptions of one respondent in subsequent interviews with other respondents. I could also compare one student's account against that of others who had been part of the reported event.
2. Conversations with the lab TA (Maniaci), instructor (Pipa), co-founder of the class (Maughmer), a professional engineer who had recently hired Sailplane students (Peltier) and Department of Aerospace Engineering Head (Lesieutre) were all useful in adding context to the student interviews. With the exception of the interview with Lesieutre, these conversations were not taped. Recollections were noted as memos at the earliest opportunity. The Lesieutre interview was taped and transcribed.
3. Two practice interviews provided further perspective. I interviewed a SPIRIT student to hone my interviewing skills. In this case, I had a thorough knowledge of the student and the topics, so I could observe how this student's responses

compared to my own observations in order to learn how student experience made itself evident in the answers to these interview questions.

4. Finally, the topics I analyzed with this data were not controversial or thinly nuanced. Such conclusions might subsequently be drawn, but they will require corroborating evidence.
5. I engaged the volunteer services of Sameer Honwad, a graduate student in Curriculum & Instruction, to provide a measure of insulation against researcher bias. A tight schedule, along with a more determined effort at training Sameer in interview techniques would have made this check more robust. He also performed two interviews that provide an interesting counterbalance to my own.

Limitations of analysis methods

The first limitation of the analysis method we encounter is that the transcription was completed by the interviewer. An independent transcriber might have provided a neutral ear that would improve the impartial rendering of the proceedings. On the other hand, having a single transcriber probably increased the accuracy of the result (since I was there at the interview) and certainly provided a uniformity of conventions used for conveying non-verbal clues.

Secondly, the interviewing and coding of the data were performed primarily by me. This increased the chance that researcher bias inadvertently played a part in the understanding of the project that is passed on to the reader. Errors of preferential selection and of emphasis are possible. It was intended that a second person would check my work for obvious bias. This could not be arranged.

Conclusion: Limitations to usefulness of the data and findings.

There are many dimensions to the question of "How do students experience project-based courses?" This study and this data must provide a strictly limited view of this question. It is limited in time to the fall semester of 2005. It is limited in scope to the Sailplane Project and therefore must be viewed in the context of the Aerospace Engineering curriculum at Penn State University at that time. Through my sampling techniques, I attempted to simulate a longitudinal study by interviewing students at all levels of experience currently enrolled in the class. A truly longitudinal study, in which individual students are repeatedly interviewed would be more rigorously able to address issues relating to development and survivorship. How does Sailplane factor into the educational experience of the student? Why do students leave the project? These important dimensions (which would provide important boundary conditions on the topics we studied in depth) could only be lightly addressed here.

Conclusion: Researcher observations on the applied methodology

In my view, the data-gathering phase of the project was successful. Having interviewed just over half of the participants of Sailplane, I have a detail-rich snapshot of the program at a particular point in its evolution. The transcripts could yield data on a number of research questions relevant to the student experience of project based courses.

An important lesson for me was the importance of maintaining a firm focus on the research topic. The structure for the inquiry that I proposed at the beginning served well as a guide for remaining on-topic. The structure of the interview protocol did not change significantly during the data-taking period. Furthermore, coding of the transcripts confirmed that a large majority of the discussion in the interviews was relevant to the research question.

It was immediately apparent that the students in Sailplane care deeply about the class. It is a feature that is central to their Penn State experience and they feel strongly that it is immensely valuable to them. For this reason, they went out of their way to assist in this research (which they perceived would be beneficial to the program). From my experience as an instructor at Penn State, this group seemed generally above average in their ability to express themselves and in their sense of themselves. They could formulate a coherent response even to open-ended questions like, “What is the teaching philosophy of Sailplane?” This in itself might be a finding related to the kind of student who is attracted to PBCs, though my data cannot support such a broad conclusion. Nevertheless, it is still surprising that we had 100% willingness to participate in the study, 90% positive response to our requests for an interview and 100% on-time appearance at the appointed place for the interview. Pipa and David Maniaci, the graduate student T/A were effective key informers. It was easy to talk to these students on a topic of great interest to them.

As an interviewer, I tried to keep the tone of the interviews informal and loose. I tried to enlist the respondents as partners in the quest for insight into the workings of Sailplane. I tried to present myself as one who shares their enthusiasm for experiential learning, but one who was not knowledgeable about Sailplane. They responded well to this, pointing to areas of importance and trying to illustrate important distinctions.

In several instances, by encouraging the respondents to expand on topics they themselves had brought up, I found that they would launch into areas that appeared elsewhere in the interview protocol. For example, as time got short in S08, I felt that it was most important to dwell on that person's unique perspective as a ninth semester participant rather than on details of the course. Given a chance to cite 'other areas that of importance to an understanding of the course', she brought up grading and evaluation – precisely one of the topics I had skipped. In another instance, a respondent who I had judged not social in nature, nevertheless would not let the interview end without discussing the social aspect of the program. These (and other) examples reassured me in two important areas: the students felt free to volunteer topics they saw as important (that is, the research partnership was strong); and the structure of the interview protocol was reliable (since these topics of importance were included in the protocol, but had been skipped).

Since the group is so close, I felt that there might be a danger that the results could be skewed if the respondents 'coached' each other. If this were so, one might expect that the responses to particular questions would get more and more uniform as the semester progressed. I did not feel this was the case. I also did not see any evidence that close friends were giving uniform answers or that respondents seemed prepared for particular questions.

My limitations as an expert interviewer constitute just one of several bounds inherent in the following analysis. Another one is a survivorship bias, which must be kept in mind. Many of the interviews were far-ranging in scope. The range of personalities represented among the respondents was similarly broad. Yet only issues and details that lent themselves to clear analysis are included in this discussion. There are several topics that do not find their way in, because, for instance, they were difficult to discuss in a semi-formal interview.3 I might also have neglected to ask about important concerns.4 Or, when I did ask, I might have found the responses contradictory or confused. In some cases, neither the students nor I had the expertise to apply the appropriate focus needed to get the data that would lead to a firm conclusion. Data in any one of these categories simply disappeared from this account.

The respondents were overwhelmingly students who were successful in the Sailplane context. I did contact one student who had left the program after a two semesters in the program (S07). Also three of the respondents were new students, so it could not yet be know what the character of their tenure might be. Thus, though a range of experiences is represented in these data, the students' level of satisfaction with the program was not a factor in the sample selection process. Therefore, I would expect that

[3] For example, the question of the part gender plays in how the students participate and succeed in Sailplane bears further inquiry. Is Sailplane gender-neutral? Or does it reinforce male dominance in a subtle or explicit way? I asked this of several interviewees – including three females – but they treated the topic matter-of-factly and no light was shed on the issue.

[4] I did , however, give each respondent the chance to tell me if I had left anything out – and several did suggest areas that I had covered too lightly.

the chances that I would hear a positive account far exceed the chances that the full range of possible responses would be heard. For these various reasons, I might have missed important features in the Sailplane landscape. Nonetheless, the features that emerge from the subsequent analysis are ones that were given importance by these students at this time.

Chapter 4 Storyline Narrative

At its most superficial level, the first outcome of this project is to provide a description of how students experience Sailplane. How do project-based courses work? What expectations do the students bring? How are the processes of growth (biological and professional) made evident in this environment? How do the students describe what they are going through as Sailplane participants? This description of the typical experience by those within the course will provide a background against which to understand the extremes of experience. Certain themes that emerge from this description will be examined later in more detail.

Recalling their K-12 experiences, most students cited naïve and general influences that suggested that aerospace engineering might be the career path for them. Many cited their parents as being important influences on their choice of aerospace engineering as a direction. ("My Dad has a big influence over me because he's a pilot", S06, line 1224). S13 contributed this recollection:

> I knew engineering was kinda for me because science and math are my good subjects and I enjoy them…About midway through senior year, the History Channel was showing some show about planes. I was sitting there fascinated. And like I enjoy going to airports. And I was like, 'You know what? This is pointing to something.' (S13, lines 64 – 71)

Having chosen to matriculate at Penn State, often on the strength of the Aerospace Engineering Department, they are excited to learn about a program like Sailplane that gives them a chance to get involved in the discipline immediately. The reasons students cited for joining Sailplane fell into five categories (See Table 4-1). These reasons were forward-looking. That is, the students were not joining in order to continue a positive experience they had had in high school. Few students could cite any similar lab class or experience in school or out before joining Sailplane. Rather, the students, who were mostly freshmen when they joined, were focused on how Sailplane could influence their education and career ahead. As S04 said,

> I was at FTCAP for Schreyer's Honors College and Pipa, the one that runs it, came into our class and just said, 'This is my class it's very cool you should take it.' And, I needed honors credit, so I said, like okay and I decided to take it just .. pretty much on a whim just because it sounded interesting. (Transcript S04, lines 43 – 48)

In contrast, S06 cited the hands-on experience as the reason for joining:

> When I heard of Sailplane, I just got so excited, because it's not sitting in lecture learning about, you know, things that don't really have an application yet. They will, but you don't know that. And in Sailplane you get literally like thrown into all this hands-on work. *You're* building something that will fly. I mean that's your career. That's what you want to do. So just getting into it 4 or 5 years early is amazing. (Transcript S06, lines 1229 – 1236)

These five non-exclusive categories of reasons for joining the project were cited by sixteen students:

Table 4-1: Reasons for joining Sailplane

Category	**Examples (respondent)**	**# of respondents**
Whim	My FTCP advisor was Pipa (S13) A friend brought me in (S01)	12 (S01, S02, S03, S04, S08, S09, S10, S11, S12, S13, S15, S16)
Expectation of hands-on experience	Designing something productive (S07) NOT like my other lecture classes (S06) Hands-on experience before junior year (S11)	9 (S02,S05, S06, S07, S08, S10, S11, S12, S14)
Social reasons	A mix of ages (S04) Good atmosphere; good people (S10)	4 (S01, S04, S10, S15)
Experience pertinent to career interest	Experience to narrow career interests (S06) A chance to explore my interest in composites (S12)	4 (S05, S06, S11, S12)
Honors credits; avoiding certain classes		2 (S10, S16)

The Sailplane class meets at 8 am on Tuesdays and Thursdays during the fall semester. Therefore, for many of the students, the Sailplane class was their first experience of a university classroom and many had the same recollection:

> Oh, I walked in and all it was really different from all my other classes because as soon as I sat down, like, the whole class is you know talking and laughing and everyone knows everyone and I was just like 'hmmmm what's going on?' {both laugh} So..Yeah, it was definitely a whole lot different on the first day than like any other class because most classes you come in and it's like a bunch of zombies sitting there and there may be a few little discussions going on here or there, between a couple people, but that's about it. So, it was …it you know .. it was a good first impression. It didn't take too long to sort of you know … get uh accepted and be one of the you know be joking around like everyone else also." (Transcript S02, lines 153 – 163)

The first days and weeks, in the context of the transition from high school to a big university is a daunting experience. The word "intimidating" was used by eight interviewees. S08 expressed it this way,

> I mean a freshman after all a freshman is a freshman. You know? Like it doesn't matter . Aerospace or not, they don't know what's going on! And your first semester you just kind of sit there .. staring at the board and thinking, "I'm going to fail this class. I'm going to fail this class. (laughing) I'm going to fail this class." 'Cause you know they're talking about drag polars and Reynold's numbers and you know all this stuff and you're just like, "I have no idea what's going on! I can't even spell empinage. I'm going to fail! This is horrible!" (Transcript S08, lines 231 – 239)

In my visit to the Sailplane classroom during the second lecture period of the semester, I can confirm the sense of animation (and segregation) in the room. I, too, found it to be an intimidating, but not unfriendly atmosphere. The freshmen were …

> …the ones that were just sitting by themselves and not talking, you know what I mean? Generally in the front of the class. While everybody else was laughing and carrying on, you knew that they knew each other already, so … It was pretty easy to tell the freshmen. (Transcript S05, lines 34 – 344)

Someone had brought a snack to blunt the early hour. When Pipa arrived, conversation did not stop, though attention was immediately focused on him in the front of the room.

Throughout his presentation, Pipa maintained an easy banter, addressing students by name and with easy informality.

Freshman experience

A two-hour lecture is delivered once per week by the instructor. A design lab, supervised by a teaching assistant (TA) also meets four days per week. Sailplane students must devote four hours per week to lab activity. (For upperclassmen, this requirement is reduced to three hours.) Students register their attendance through a sign-in procedure. Since the numbers of students are growing beyond the ability of the faculty to supervise, entry to the program is now limited to freshmen and sophomores only. The long-term interests of the program are best served by admitting students who will continue to participate for a long time. Freshmen and sophomores receive one academic credit per semester for their participation in the lab and lecture. Juniors and seniors receive two academic credits per semester. A total of twenty credits may be earned by students throughout their career. Of those credits, eleven can be applied towards degree requirements. Sailplane credits can be applied in lieu of certain required aerospace courses (senior capstone design, for example) (Wheeler, 2003).

In the first week of class, the students are divided into teams. For freshmen, these team assignments are arbitrarily applied by Pipa[5]. Each student becomes a member of two teams: A class team and a lab team. The class, or “design team” performs theoretical exercises that apply aerospace principles to some aspect of vehicle design. Generally, the focus of the class is to create designs that will be produced in the labs in future classes. As an example, one class team was tasked with investigating new materials in order to report to the class on materials that

[5] Freshman role-experience, S03, ref1, line 215-221; Freshman role-experience, S13, ref 1

showed promise for application on a sailplane. However, if a design problem is encountered in the lab, the class is used as a forum to investigate the problem and to forge a class decision on what should be done

The lab teams performed the hands-on work of fabricating the current sailplane. This work ranged from endless sanding of fiberglass to steel welding to fiberglass layups. The work of the lab teams defines the progress of the class. This work is the sailplane taking shape. Most freshmen attend lab with their lab group, but the obligation can be fulfilled by attending any of the lab times in order to accommodate busy student schedules. Students would routinely come to the lab at convenient times and pitch in with whatever was being done. Since team leaders seldom knew how many students were coming to the lab, it was hard for them to make the most efficient use of the weekly lab periods in order to progress toward semester goals. This was one reason that planning at the project level was not effective. Deadlines and goals for project work were set according to class (semester) timelines and not project imperatives. This view of Sailplane as a 'class' rather than a 'project' is consistent with the role of the Sailplane class as an honors practicum offering in the Aerospace Engineering Department curriculum.

Both the design teams and the lab teams were vertically integrated. An ironic result of the vertical integration is that freshmen seldom hang out together6. New students are invited to integrate into the project on the basis of their lab group, not their (lack of) experience. In the context of the teams, the seniors would mentor and teach the underclassmen and in the context of the teams, the students could measure their own progress.

> One of the goals of the course was to try to enhance the educational process of the underclassmen. And so, the groups were usually led by a senior and there may have been one to two seniors in the group and then maybe an equal distribution of juniors, sophomores, freshmen. (Transcript S15, lines 138 - 142)

[6] See, Transcript S05, lines (from Freshman role, S05, ref 3)

The teams represented a supportive learning environment in which younger students were encouraged to perform to their ability and beyond.

> The way that we worked it, if there was anything, you know, sort of complicated, they would say, "Alright, we're going to do a drag build-up, so … here's a picture of the plane. What we want you to do is just measure off these sections and then give us all your measurements and then we're going to type up a program and we'll show you what it does." So, they had me do something that I could do and then they explained what they were doing with my numbers. You know, because I couldn't really do any thing with those numbers yet, but they explained what they were doing, so I could kind of understand it. (Transcript S03, lines 248 – 259)

If they failed, they were not punished, but rather were encouraged to re-do the task correctly. This point should be emphasized. S02 put it like this:

> Something else that happened that I didn't expect is like in Sailplane class, you run into a lot of things where you make big mistakes. I mean you make them, but people catch them and tell you about them. You learn from making a lot of mistakes in the first year or two just because you really don't know much. After you make a mistake, then you talk about it in the class and figure it out and you don't forget it, because whenever you do something dumb, you don't forget it. So it's not like everyone just says, "Oh, you're an idiot." They just kind of laugh about it. [You] learn through making mistakes a lot in the first few years. So, it's kind of something that I didn't expect. (Transcript S02, lines 489 – 502)

In a highly competitive engineering curriculum outside of Sailplane, students seldom take risks because when those risks do not work out, the result is a lower GPA. But here within Sailplane, a student is expected to learn through making mistakes and the class grade is based on a mix of peer evaluation, presentation performance and a final report. This puts the emphasis squarely on visible team work. This method is not uniformly embraced. Here are two perspectives on how the grading system works in Sailplane. The first was the predominant view.

> The course grade is based on your peer evaluations. They're most important. And teacher evaluations and um the commitment that you have… Your peer evaluations are very important, which means that you have to be an effective team member. You have to help; you have to communicate properly. You have to be there and make sure that the project is going smoothly because if you are no help at all [to your team], your grade will reflect that, because the peer evaluations are so important. So, it's not a really big concern for me, because I've done well in past years and I have more experience now, so

> I can help more. And I'll be there on lab nights, because I made that commitment. So, and um the presentations, I'm pretty comfortable speaking in front of the group now, so I mean that's pretty good. And then, um, we can all help each other on the report that we have to produce at the end of the year, so um that hopefully will go into having a good grade. (Transcript S06, lines 1731 - 1751)

> Well, I did I received a B once and an A- once in Sailplane and yet on the current airplane, 35% of it is .. my design. And it's significantly more than any other person in the class and it's just like I think for me, like being a kind of a higher end student, like if I put in the same amount of hours and the same amount of productivity, it wasn't always good enough in the eyes of the instructor" (Transcript S14, lines 63 – 71) "In a normal class, you have homeworks, you have quizzes and exams and maybe a project. And that's what you're graded off of. And in Sailplane, like you have to get a grade somehow, so like you do have your lab notebooks, and some design presentations and design reports or lab reports. {uh huh} But, there's not really any solid metric to be guided off of , so there's not an indication of how many hours someone put into a certain component and like whether or not, those hours were effective hours That's really what made a difficult for me, I think. (Transcript S14, lines 43-55)

> What happened to me when as a team leader, I kind of went off on my own and re-designed the thing. [Those who go off and do significant work on their own], their grades wouldn't necessarily reflect what they've contributed. And I think you know, engineers being super-competitive, when you get a B, like most of them would be like, "Why would I be in the class again?" (Transcript S14, lines 1314-1323)

Stature in the class was gained through expert work performed in the lab or class teams. By the end of freshman year, a subtle process of sorting has begun through which the future leaders are identified. This process is based on performance within the team. In a sense, each freshman is given more and more freedom or responsibility to perform until he or she pulls back. Throughout, they feel supported and encouraged in this process.

> If the freshman has trouble and asks the senior, they're usually willing to help. But, it's not like the senior will lower the standards of knowledge to help the person exactly… You have to make your won way, but you also have to know when you can't. And to find out how. And if you make a mistake at some point and the senior gets annoyed at you, that happens, too. But if you just sit there and wait for the senior to tell you, "Do this" and tell you exactly how to do it, they might as well have done it themselves (Transcript S16, lines 522 - 532)

The teams were also the center of the social fabric, like small families in a community. For the freshmen, being assigned to a team was particularly meaningful. Seniors on the team are given personal responsibility for the success of the new recruit. The freshman in turn, is invited to make the success of the team a personal responsibility. The following extraordinary quote traces this complex relationship. It was contributed by a junior who clearly remembered this moment in the past:

> I hope that I've added a certain amount of creativity to the group just whether it was my questions or my inquiries and I hope that I put in a certain amount of input that helps further the project along. I hope that, you know, I had a good influence on the team. I hope they like me as a team member. And so, then, I'll get more responsibility in the future. And, I hope that responsibility goes somewhere to produce a good project. (Transcript S06, lines 2098 – 2105)

Note how the relationship with the team, the contribution of the new person to the project success, as well as the path to greater responsibility on the team, are all expressed in personal terms. To be on a team was to belong. It was through the teams that seniors would reach out to the freshmen and bring them into the fold.

Each fall, there was an exercise that was completed jointly by the senior(s) and the freshmen on each team as a way to get to know each other. In the fall of 2005, this exercise was to build an egg glider. Each team of freshmen paired with seniors had to design and build a glider that would hold an egg aloft for the maximum amount of time. The experienced senior would be expected to produce a design for the glider and the freshmen would build and fly it. The prize was bragging rights. This exercise was an important rite of entrance. It was while working on this project that the freshmen were made to feel a part of the team.

So what can the freshmen actually contribute to the progress of the project and how do they learn how to do this? Table 4-2 lists several roles that a freshman with promise might be expected to engage in during his/her first semesters.

Table 4-2: Appropriate activity for new recruits during the first year on the project

Role	**Source**	**Class**	**Coding Reference**
To 'See' or 'hear'			
"…you just kind of look at it to kind of understand it and recognize it visually, but otherwise, I don't think I understood a lot where it was coming from	S06		F.Role, Ref2
"At the beginning, I was like you know learning and picking up stuff and watching people a lot"	S07 rev2		F.Role, Ref1
"Like hearing those concepts and having those things explained at least at a basic level before I even got there, so stuff that I heard was more familiar	S07 rev2		F.Role, Ref2
"Your first semester you just kind of sit there … stare at the board and thinking, 'I¨m going to fail this class. I'm going to fail this class. I'm going to fail this class…'"	S08		F.Role, Ref1
"I had no idea what was going on first semester. I just, you know, tried to soak everything in."	S08		F.Role, Ref2
"I just show up on Wednesday and whatever he's doing then, I pretty much just tag along."	S13	1st year	F.Role, Ref2

"I think in terms of instruction, I don't think I've learned a ton, because I haven't done much…I have notes on stuff now that I had no idea, but I figured it'll help me in the future."	S13	Frosh	F.Role, Ref4
"They were able to pick up some concepts that they wouldn't normally get until they were juniors and seniors."	S15	Alum	F.Role, Ref2
"…I'm thinking 'They're standing around not doing much!' There's been more than one time I've gotten annoyed at a freshman of some sort … and I'm *also* a freshman! I shouldn't be saying this about them!	S16	Frosh	F.Role, ref2
To perform tasks			
"Right now, I think the freshmen are more grunts, I guess you would say, than thinkers."	S05	Frosh	F.ole, Ref5
"First semester, … I remember I did a lot of sanding."	S10		F.Role, Ref1
"My freshman year, it was all sanding in the lab"	S11		F.Role, Ref1
"For the freshmen, I mean, they can't really do too much analysis. They don't have enough knowledge to do it. So, fabrication is the only thing they can do."	S12		F.Role, Ref4
" [Experienced students will] tell you what to do and you'll do it."	S12		F.Role Ref1
"...they're constructing stuff, like they have ... finished or partially finished products that they can say, 'Yeah, we worked on that.'"	S13		F.Role, Ref6
To perform documentation tasks:			
"They don't just sit stand there for the semester watching us do work… they can't do a lot of like the calculations…But that doesn't mean that they are useless…they can make all the drawings and stuff like that that we are capable of doing, but they can do just as well, too.	S08		F.Role, Ref6

"…we tell our freshmen to present because we want to get them more involved. So, the presentations are sometimes not as technical as they would otherwise be. And their just kind of funny because freshmen, they don't always understand what they're saying out loud."	S11		F.Role, Ref4
"When I was a freshman and a sophomore, we used to spend a lot of late nights … right before a project or a presentation was due doing the work.	S09		F.Role, Ref3
Other perceptions of appropriate freshman activity:			
"I would say characteristic of your first year, [is] the activity of becoming fully integrated."	S06		F.Role Ref3
"…freshmen have to want to understand…They have to be willing to ask questions and poke stuff in lab and say, 'What is this?'"	S08		F.Role, Ref9
"On the fuselage, I was very willing to let the freshmen you know ruin chromolly tubes. And it turned out to be really good because when I got moved out of the fuselage group, they were able to keep constructing it, maybe not as fast as someone who had four years of experience…	S14		F.Role, Ref5

To some, the primary beneficiaries of the Sailplane project are the freshmen. It is an exhilarating time characterized by 'intimidation' by the immensity of what must be learned, a determination to ascend through the learning curve and to do well for 'my seniors', and pride in what is accomplished. Even many years later, the recollection of freshman year in Sailplane remains vivid. Freshmen are teased, but they are also coddled as representing the future of this Sailplane class which the seniors value so highly. The seniors recognize that they, too, were clueless not so long ago. They take pride in the knowledge they have gained and they express that pride by taking the time to teach the younger students the principles of aerospace engineering.

Sophomore/Junior experience

If it is the job of the freshmen to become acclimated into the Sailplane community, the next two years are spent quietly gaining experience and stature in the group.

> I had no idea what was going on first semester. I just tried to soak everything in. And then second semester, there were a couple more freshmen that joined and they had like the scared blank look on their face and I was like 'I don't really know what's going on, butttt kind of do this.' And that's you know like maybe I picked up something. And then the 3rd semester, you know, was like you've had a whole year, you've seen most things twice and there was a whole new group of freshmen and you know they're looking to you because you're just enough older that you know what's going on, but you're not quite scary like the seniors. That was when I really started to figure stuff out. (Transcript S08, lines 296 – 307)

Sophomores 'know where the tools are kept' and can answer simple questions. Trust in their nascent abilities is beginning to develop. Some of them will even be given responsibility for simple tasks. Completion of these tasks in turn leads to increased stature in the project.

During these interim years, an interesting dilemma develops. Since stature was gained by accomplishment on the team work, there was a urge to stay with a team and to become an expert in a certain area. One student, not interviewed, was cited repeatedly as being an expert on questions relating to the leading edge of the wing because of his long tenure on that team. Any substantive question relating to the leading edge could be confidently referred to him. His stature in the project came from his expertise. At the same time, there was a palpable sense that the class was a good place to explore a diversity of interests within aerospace engineering. Thus, wider experience might be expected to be in the best long-term interests of the students. To join a new team, however, meant returning to a position of less stature in the group.

> I'm getting pretty good at machining and things? So, in the fuselage group, they can ask me to do things. Or maybe even ask me questions now, you know. But, if I went to some other group, it'd be just like being a freshman again. I wouldn't really know too much. And they probably wouldn't put much faith in the work that I do, because I don't have any prior experience." (Transcript S03, lines 452 - 458).

Here is the other viewpoint, voiced by a super-senior:

> Somebody works on a project a couple of semesters, they become more of an expert. But then they probably get bored of doing the same thing over and over again. That's why people switch it up. And because you can switch it up, you become more diverse. And being diversified is definitely a good quality. You know, being able to do structures and aerodynamics. (Transcript S10, lines 960 – 966)

At the end of the sophomore year, many of the Sailplane students gain entry into the Aerospace Engineering Department. There is no evidence that being in Sailplane extends any advantage for admission into the major. During the junior year, however, being a part of Sailplane provides a distinct advantage. While the typical student is gaining exposure to aerospace topics for the first time, Sailplane students have been twice exposed to the fundamental topics and principles.

> The subject matter is very important, especially in your junior year when you have all this in each of your classes. So, at least, you're not completely floored by all this new material being dumped on you. You've seen it before and now hopefully maybe you can apply it." (Transcript S06, lines 1718-1722)

Beyond that, Sailplane students will have already gained an intuitive sense of how the theoretical principles operate in the real world due to their work in designing and building a flight vehicle. Furthermore, since juniors in the major all take the same classes, Sailplane students can expect that they will have ready-made study groups consisting of Sailplane friends. Thus, the long hours in the lab during their first two years now seems to produce some significant advantages for the Sailplane juniors over their non-Sailplane classmates. Does this boost translate into an improvement in GPA in the required aerospace courses for Sailplane students? According to Dr. Lesieutre,

> I am sure you are aware Sailplane is nominally an honors course. So, already there's a difference between honors students and non-honors students or largely non-honors students. So, it's not clear that the differences we see between Sailplane students and other students are completely attributable to the course... But I do think they benefit from having this exposure to the integrated view of aerospace [engineering] as vehicle integration from the beginning of the freshman year. A lot of the other students just chug through the math and science and engineering graphics courses that freshmen and sophomores have to take and they haven't made a connection with aerospace until they're juniors. The Sailplane students get it on day one. I think that's of great value and it effects the way they approach their other courses, I think. (Transcript F17, lines 288 – 304)

Now, it is the non-sailplane students who feel a measure of intimidation in the face of the large amount of new material to be learned. For Sailplane students, the attitude is "Oh, this is what we have been doing all along in Sailplane class!"

Senior experience

Seniors, by virtue of their years in the project and burgeoning aerospace engineering knowledge, determine the pace and the direction of progress in the class. They are the boisterous group in the back of the room that sets the conversational tone with the instructor up front. They are also authority figures, leaders, and decision-makers. They are responsible for the work and the learning that takes place within their teams. They determine the team-wide coordination. They must also understand the limits of their knowledge and when to ask for help from Pipa or some other faculty member. The seniors must train underclassmen (so they can confidently hand off the fruits of their labor), assure that the work of the teams will perform as designed and also to produce the designs that subsequent lab teams will build. According to S15,

> The seniors take a prominent role, mainly because they're the ones who if there is something that has to be done, or something goes wrong, they're the ones to figure it out. Everyone looks up to them. The seniors are the ones who take charge in each section. It's like the seniors are given a group with freshmen and sophomores to teach what to do. … The seniors are definitely the driving force of the whole; the main people of the class. (Transcript S15, lines 506 - 516)

Seniors feel a responsibility to pass on as much of their knowledge as they can. There is a sense that if knowledge is not passed on, it will be lost. Passing on knowledge is fundamental to the class mission, even if progress on the sailplane projects is compromised.

> So you're trying to pass that knowledge along while you know still moving the design along. And so, of course you're not going to finish something every semester, but I don't think that was ever anyone's intention. It's more of just learning and you know kind of like a supplement to the Aerospace program. You know, you sit in class and you hear what all of these things are, but then you know the 36 of us get to go to lab and actually see what it is and play with it and you realize why it works. (Transcript S08, lines 659 – 667)

If there is a senior in the room, that person naturally takes charge. If several seniors are in the room, they collaborate to make the most of the space and personnel available. They might assign the freshmen to a task, or they might take them aside and work with them on some outstanding problem.

The seniors have worked together on Sailplane for four years, so they form a tight cohort. This is expressed through very close friendships and joint activities in and outside of Sailplane. It seems to be the senior's prerogative to have fun in the class and lab. I asked one freshman, who had been in the class for only a couple of weeks, if he could distinguish sophomores from seniors:

> Um….uh sort of. Um..the big thing is the way they dress. Plus, the seniors seem to know each other best and they have, you know, the greatest time and they joke the most, they laugh the most, they you know carry on the most. The less they do, the less a person you know jokes and all that stuff, by my grading system, I guess you would say the lower year they are. (Transcript S05, lines 630 – 636)

There was no clear consensus about whether Sailplane was a significant advantage for these seniors in finding work. There were no significant skills or experience that the students could consistently point to that they thought would help them with their impending careers. Rather, a common viewpoint was:

> And also, just the education level of Sailplane, the hands-on and everything, it prepares you for the real world. Like what you expect from a team-oriented company who does big projects, you know, it hopefully will be similar to

> Sailplane so then I won't feel so overwhelmed by that atmosphere. (Transcript S06, lines 1722 – 1727)

Sailplane students are seen to have some added skill in making presentations, but otherwise they do not stand out inordinately from their peers. I had a conversation with a practicing engineer who routinely hires about ten interns per year from across the country. He had hired Sailplane students as interns and had also recently hired a Sailplane graduate as a full-time employee. He was only superficially aware of the Sailplane class. Nor could he cite any traits, skills or advantages that distinguished Sailplane students from others.7

There are indeed many kinds of experience and skills that seniors can point to that they have acquired in Sailplane (See Table 3), but none of them is unique to Sailplane. In many cases, the skills are only tangentially related to what they expect to do as engineers. One freshman noted that his reason for participating in Sailplane was to learn about the processes and skills that as a design engineer he would not have time to do, but which he should understand in order to be a good designer.

> I hope it gives me that hands-on that a normal engineer might not get. Which might give me a better understanding into how to make it; to have it done. Sitting in front of a CAD program for a simulator and saying, 'This wing's not going to work' is a little different than saying, "I've seen one of those fly and it doesn't work." … So, hopefully, I will be able to think in broader terms than someone who has had one class in aeronautics and one class in propulsion and one class in this. I hope to have a little bit more knowledge of the putting them all together. (Transcript S16, lines 1037 – 1032)

Sailplane is not seen by these students as training program to acquire unique skills that they will use in subsequent jobs. Rather, they see it as a fun and rewarding learning environment where they can immerse themselves in an aerospace engineering design and

[7] Peltier, Joel in personal conversation, 24 October 2005. (Memo 29)

fabrication laboratory from their very first days on campus. A new freshman faces a large and boisterous group of students who seem to know a tremendous amount about a difficult and exciting discipline. Once in the class, that freshman comes to value the intense, but cooperative, vertically-integrated teams where older students mentor younger ones through long hours in the lab. By the time that freshman is a senior, the entire

Table 4-3: "What Sailplane students are really good at."

Skills and experiences students cite as accruing to participants in Sailplane. Note that the text examples are paraphrased. Some respondents cited more than one reason.

Category	**Examples**	**# of respondents**
Teamworking	They can better handle people Carrying ideas from one setting to another I am better at working in teams now Employers ask about my group work	**10** (S01, S02, S04, S06, S08, S09, S10, S14, S16, F17)
Hands-on experience	*You're* building something that will fly I like to work with my hands Courses teach you why, but not the implications Get out of the chair and get my hands dirty	**9** (S01, S02, S06, S07, S08, S12, S13, S15, S16)
Working with materials	Properties of fiberglass and how to work with it A new material means new construction methods Generalization of composite experience to other (non-Sailplane) applications. Lexan, foam, chromolly steel, fabric	**9** (S02,S05, S06, S07, S08, S10, S11, S12, S14)
Design process for applying aerospace principles to building a flight vehicle	How much work goes into a single part Not the 'right way', but a clever way that works and is light and strong. 'Oops and start again' gets you ahead Seeing the entire design cycle Understanding the terminology	**7** (S01, S05, S06, S11, S14, S16, F17)
Professional skills	Presentations Engineering reports Calculations Being able to learn what you don't know	**6** (S02, S03, S06, S07, S08, S11)
Other skills	Welding, fiber-glass layup, flying, machining, teaching	**4** (S01, S02, S03, S11)

landscape has changed. The large group of 'experts' has all moved on. What remains is a band of very close friends, now confident in their own knowledge, who have experienced so much together since that first 8 am lecture at the dawn of their university careers.

This picture of the learning environment in the Sailplane class is rosy because for most students the experience of Sailplane is hugely positive. It is not perfect, however. Two respondents related the tale of a student who had extensive experience with building and flying sailplanes who joined the program as a senior. This senior expected that his experience would be valued. It was not. The students were not as much interested in his expertise as they were in gaining their own expertise. They were suspicious that this or any person had the right answer. They were too possessive of their own new learning to trust his.

> We almost breed our own way of thinking …[students who join as] seniors don\t get it. Freshmen and sophomores are more inquisitive. You learn to question. Freshmen and sophomores learn that it is okay to not know what is going on. It is not a sign of weakness. [In this course,] you will be continually learning. *I* am learning from the freshmen. They bring fresh ideas." (Wheeler, 2003, p.4)

Evidently, the process of acquiring experience in the program is the glue that holds it together. That this attitude limits what the class can accomplish (in terms of building working sailplanes) is of little concern to the students. "My goal is for learning to happen," said Dr. Mark Maughmer, co-founder of Sailplane. "Other groups have a goal or a deadline. I can back away when it is ceasing to be a good, positive experience."[8] This in turn underscores the fact that the task of building a functioning vehicle is not the primary objective of the class. As a sophomore put it,

> We are learning. We are not focused on finishing a sailplane. You are setting a goal for yourself … What do you want to learn? There are no set expectations what will be taught." (Wheeler, 2003, p.5)

Learning the details of building a sailplane takes second fiddle to learning aerospace principles in the context of a sailplane project. "There is less of an emphasis on finishing. The emphasis is on learning."[9]

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[8] Wheeler (2003), p. 3
[9] Ibid., p. 5

Chapter 5 Analysis of the interview data

In analyzing this set of interview data, I sought detail about the structure and organization of the class. I was also interested in the dynamics of the class. The interviewees were in a unique position to provide insight into the significance of the class to their education, the characteristics of the class that boosted its effectiveness, and what, precisely, they gained from having been Sailplane students over several years. The reliability of the accounts was verified by triangulation across the different interviews and by my own observation of the class and lab during the fall semester of 2005.

Beyond the facts of the experience, I sought to examine the manner in which the accounts were communicated to me. I took repetition (both within particular interviews and among interviews) as evidence of emphasis. I noted surprise turns of the interviews, such as when a respondent would begin by answering my question, but then would turn the conversation in a surprising way. Such a turn, or the injection of a seemingly unrelated point into the conversation, was interpreted as an indication that the speaker felt some urgency about the matter. If I could verify that emphasis elsewhere, then I was comfortable in ascribing importance to it. I paid special attention to “code words” that seemed to have special significance for the speaker, or which seemed to be used idiosyncratically by class members. Such shared usage, I presumed, pointed to shared experience. Finally, I looked for patterns or ‘threads’ that wove through the fabric of the interviews. These themes might not find prominence in a particular interview, but became visible when the entire data set is considered.

Differences from "typical" aerospace classes

One thing that most everyone who has experience with Sailplane notices – participant and observer alike – is the vitality in the class that is starkly at odds with the typical engineering classroom. Despite the fact that these students are engaged in what may appear to be exacting work (designing the leading edge of a wing or exploring cabling systems for controlling the flaps and rudder), they are excited to be there. When I visited class during the second week of the semester, the only open seats were in the front of the room (where new students sit). In the back, groups of older students were engaged in lively conversation. Students toward the front were not yet "accepted" into the social dynamic. "It's like a bus!", according to S05, a freshman. This I understood to mean that the classroom was segregated, in this case by status in the class, with those of high status claiming the back-most seats.

During my visit, the lecture was a review of the history of sailplanes. The seniors (from the back of the room) would question Pipa on the characteristics of the various classic designs that he was presenting. The underclassmen said little. In my experience teaching, the more interactive students tend to sit in front, with the level of interaction dropping off with distance from the front of the room. That order was reversed in this case.

There are other ways that Sailplane contrasted to the typical aerospace engineering class. The students seemed to take delight in these differences. Eight students provided twenty-two examples of ways in which Sailplane is different. These examples can be grouped into four general areas, as shown in Table 5-1.

Table 5-1: Differences between Sailplane and other classes/labs in the Aerospace Engineering curriculum

Contrast	Instances	Example
Differences in approach to learning & teaching	iv,vii,xiv,xv, xvi, xvii, xviii, xix, xx,	"Differences, like [Aero]306 is a structured like environment and Sailplane is a completely unstructured learning environment. So, you're going to learn what you *want* to learn. And if you don't want to learn something, then you don't have to." (S14: l.666)
Sailplane is fun, *not* boring	i, ii, iii, vi,viii,x,	"I can't even think of anything that's been boring that we've ever done. {un huh} And I can think of a billion things in other classes that are boring. " (S02: l. 723)
Meeting people who become friends	v,ix,xii,	"It was immediately apparent that this class was different" (S07: l. 70) because everyone knew each other. "So, it was uh more of a group than just a normal class" (S07: l. 75)
Hands-on build/experience	xi,xiii,xxi, xxii	"You sit in class and you hear what all of these things are, but then .. you know the 36 of us get to go to lab and actually see what it is and play with it and you know realize why it works." (S08: l. 610)

Because of these differences, the students approach the Sailplane class in a different way than they do to their other classes. Some take it seriously as an activity: "Unlike flag football, Sailplane is directly related to my major choice." (S05: l. 588); while others take it less seriously: "Sailplane is still like, you know, a little school project." (S12: l.510)

The purpose of the Sailplane class

S01 voices a dichotomy that is felt by many students:

> The stated goal of the class I think is to finish the sailplane and of course everyone's going to finish the sailplane.… but to me, it seems like obviously the purpose of the class is education. Um. And I don't know if the eventual goal is to finish the airplane. (S01: l. 128)

Or, as S09 put it:

> The class, at least to me, has always been for the learning experience. And so, yeah, it may take us a number of iterations to get to the final product or to get to a spar that is actually flight worthy and or to get to a final thing. But the fact that we're learning the process so we may make some mistakes here and there so that also adds to the length. Which is why we don't have a final product or an actual glider yet, but .. to me that's that's pretty much personally the final product isn't a huge goal. It's more learning how to get there. (S09: l. 151)

Two issues are voiced here: There was general agreement among the respondents that the agenda for the class is education. (There is less agreement on what is actually learned by whom as we have discussed in the previous chapter.) At the same time, whether a sailplane will actually be completed or after all, should be completed is a matter of debate. The sides of the argument are stated by S08 and S01 as follows:

> It would be nice to eventually close it up and fly it and have, you know, a finished product for the class. But more importantly, it's been like a tool for learning. (S08: l. 591)

> It kind of breaks my heart that … that we're not going to be able to fly it. And it kind of I kind of don't like it how … the EZ-build is becoming more and more difficult to build as it gets more complicated. And I kind of want it to just, you know, get something in the air, because there's nothing like the thrill of flying something you have built. (S01: l. 1114)

The respondents broke about 2:1 in favor of the notion that the best use of the class is the educational experience, not the production of a product. Even so, there were emotional responses (as above), a yearning for professional accountability, and recognition that an ad hoc group of undergraduate students may not have the skills or the tools to finish a flyable craft. This contributed to a certain frustration on the part of some.

Two further comments are revealing about the nature of the class and demonstrate the uncomfortable ambiguity that surrounds this issue:

TW: How important is that to the project? The completion…

S02: Oh, it's not important at all. There's a whole lot of things that we've done that we just don't finish, 'cause…you know, yeah the class decides that's not what the direction they want to go, or whatever. And so, it's not it's not a huge deal, because the fun part is doing it. The fun part isn't having it there, sitting and looking at it. So…Just just the excitement of you know learning different uh techniques for building 'n designing 'n … um that's that's .. the best part.(S02: l. 1367)

TW: What about the um professional issue of completion? You know of seeing a project through. Do you think is that detracts from the education that the students get?

A15 (an alumnus of the program): Um. [8 second pause] I'm not sure if it detracts from the education that they get. I think it might I think it detracts from their personal sense of accomplishment? (A15: l.414)[10]

In a personal correspondence, Dr. Maughmer was clear about his vision for the class:

> My goal is for learning to happen. Other groups have a goal or a deadline. I can back away when it is ceasing to be a good, positive experience. We want to get across to these students our motivation for being engineers. (Wheeler, 2003)

Much as the students would like to build a functioning vehicle, most come to the realization that that is not the primary objective of the class. As a sophomore put it,

> We are learning. We are not focused on finishing a sailplane. You are setting a goal for yourself … What do you want to learn? There are no set expectations what will be taught. (Wheeler, 2003)

[10] Note: The survivorship bias should be evident here. Even those who strongly advocated finishing an airplane acknowledged that this is a class setting. The question from their standpoint might be stated as, "Is it appropriate to build a flyable craft in a classroom?" Those who are set upon producing a product may have left for other programs, like the ME SAE car, that do indeed complete projects on a regular basis.

The Sailplane learning environment

There is a clear perception among students that the Sailplane class is relaxed, informal and fun and because of that, that the students learn more. The reason that the class is perceived as relaxed is ascribed to the social atmosphere (eight respondents made this point, sometimes in multiple instances). Others pointed out that there are no tests or quizzes in this class (3 respondents). This is a place where students feel comfortable making mistakes and then correcting them. They feel safe trying new things. Should their efforts turn out to be misguided, they are confident that they will be supported by the other students (friends), who will not only point out the error, but then will provide an opportunity to correct the erroneous work. These three elements are important:

- Sailplane is a comfortable place to try things:

> We're just out there like exploring like different things 'n hopefully stumble into an answer (S03: l. 702).

- If a student makes a mistake, the error will be caught by a supportive group:

> Something else that happened that I didn't expect is like in Sailplane class, you run into a lot of things where you make big mistakes. I mean you make them, but people catch them and tell you about them. You learn from making a lot of mistakes in the first year or two just because you really don't know much. After you make a mistake, then you talk about it in the class and figure it out and you don't forget it, because whenever you do something dumb, you don't forget it. So it's not like everyone just says, "Oh, you're an idiot." They just kind of laugh about it. [You] learn through making mistakes a lot in the first few years". (S02, lines 489 – 502)

- The students will have the opportunity to correct their errors and thus to benefit (learn) from the experience:

> I think the best way to learn (and this is just my opinion) is (and it's probably a lot of people's opinion) is to do something and mess up and then fix it yourself… do something and mess up and then fix it yourself and then, in case I didn't get it

> the first time… again. I'd rather have you know a couple .. a couple mistakes and then learn a lot from them than have a couple of mistakes and have somebody fix it for me and then I'm kind of in the dark. (S03: l. 833)

> I tend to learn better from my mistakes than other people's (S13: l. 1319)

What emerges is a picture of a learning environment that is more complex than a 'typical' classroom. In the latter, the dynamic is predominantly between a single faculty member and the many students. In that setting, the students' posture is one of physical inactivity, more often than not. Here in Sailplane,

> It's I don't know I just .. I really like the .. laid back attitude of the class? I probably learn more because of it. Because you know, when you're in actual class, you're you know you're bored and things 'n .. But in this class, you know, it keeps you, I guess awake and *interested* that that's probably the word I'm looking for, you know. Because just the the friendship and the the overall like .. comfortable like .. feeling the class gives you, you just stay interested (S03: l. 633).

So, the students feel that they learn more in Sailplane. This comes about because the atmosphere is relaxed, unlike other learning contexts that they experience. In turn, the atmosphere is relaxed due to the social nature of the interactions among the students. They feel they are among friends, which in turn leads to increased learning. Some examples from the data follow:

1. The relaxed atmosphere makes learning seem 'easy', as opposed to 'work':

    a. You just absorb it through the years. I mean you're exposed to some of it during class during lecture a lot of the theory, um and a lot of it you just pick up from other students who have already figured that part out they'll pass down to you. Then you'll figure out something else and you'll pass that down to someone below you. (S11, l. 312)

    b. I've had no problems with either of those two [people]. Um..they're both funny, they're always joking you know it really lightens the atmosphere. You know, so .. it makes it makes the work fun instead of .. work. (S05: l. 606)[11]

2. Learning aerospace principles assumes added importance because the people in Sailplane are important to the participants

    a. when you're working on Sailplane, it's not just the techno aspect, it's the social aspect. Like you're joking around in lab and talking about what's going on and everything." (S14: l.1580)
    b. Friendship based on working on something they're both interested in? Yeah. Yeah I mean that's a lot of the times, how it starts. {uh huh} Um… and then either at that point they'll either kind a stay like that or they'll move on to be better friends that we find other things in common" (S02: l. 1520)

3. Because of this learning and these friends, Sailplane students develop a self-identity as an aerospace engineer

    a. I think Sailplane like really.. I'm so glad I did it. I was actually thinking about that on the way to this meeting I was thinking, "Man I'm so glad that the advisor I had recommended me for this class." Because without this class, you know I'd have the regular core engineering courses I *never* would be experienced in aerospace. So by the time my junior year rolls around, I might be entering a major that I had no you know I had no clue about. .. Sailplane really really helped me make my decision that this is what I like to do." (S03: l. 1054)

    b. Well it, the best aerospace engineers are the one that have fun doing it. {Uh huh} So, that's why. I mean .. you sorta I guess weed out the people who don't want to be engineers. I mean if you're not having fun working with other people working on the sailplane … And if you don't *like* that part, then you know, there's other things you can do. But, .. like I definitely I find that like the fact that I'm working with people (and it *is* sort of like .. going to the movies), I mean {Uh huh} you do just talk to each other. Just converse. Maybe nothing related to Sailplane, but you still have to tie your work together and work together solve problems. Solving problems feels good. (S12: l.663)

[11] Note: The code word "joking" was used by several respondents to describe conditions relevant to the relaxed learning environment. We will discuss this and other code words below.

Self-identity/knowledge of aerospace principles/close friendships built of common experiences become intertwined. One of the benefits of being in Sailplane for many of these students was that it made their choice of aerospace engineering as a major clear for them at an earlier point than others in their class.12

Traits for success in Sailplane

In the previous quote, S12 referred to a weeding process that occurs in the class. There was considerable agreement among respondents about what it took to succeed as a student in Sailplane.

Table 5-2: Traits for success in Sailplane.

Contrast	Instances	Typical comment
People skills	11	Work well with others; open and friendly; outgoing, tolerant, good motivator
Willingness to learn	5	Asks questions, stays after class/lab, curious
Drive to get things done	4	Self-motivated, possess common sense, NOT cocky

Other traits, such as “experience with building sailplanes” or “interest in aerospace” were *not* cited as being important for success in Sailplane. In fact, in a couple of instances, previous experience building sailplanes caused friction that kept new students from fitting into the group. (See the “know-it-all” section below.)

[12] We are *not* making a case for causality here. There are too many uncontrollable factors. In many cases, commitment to becoming an aerospace engineer was a reason for joining Sailplane, not the other way around. Nevertheless, to a high degree, these elements are closely associated in Sailplane.

Resources for learning

The objective for Sailplane is to have this class of (nominally honors) undergraduate students design and then build a sailplane that meets criteria posed to them. Or, as S10 put it (l. 844), the purpose is to “make a sailplane while having fun.” The business of the class is conducted within a “relaxed” learning environment. Clearly, the students need a structure of support if they are to accomplish this ambitious task. How do students get the help they need? How do they know that they are on the right track? Where do they go with questions? The hierarchy of authority is well summarized by S03: If he had a question, …

> … the first thing I would do is go to group members. And then if they didn’t know I might ask someone else in the class .. you know that I thought might know you know like maybe someone who was really knowledgeable in whatever aspect. And um if *they* didn’t know, then I guess I would go ta .. probably Dave if ‘cause he’s usually in the labs, so he’d probably be the next person and then … um .. if all else failed, then we’d go to Pipa. The reason we wouldn’t go to Pipa first is ‘cause he’s not in the labs with us, you know? (S03: l. 677)

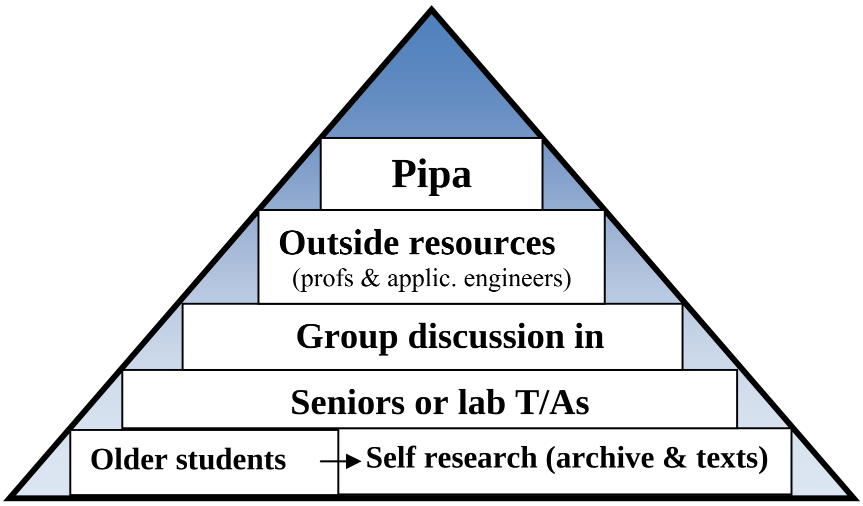

Figure 5-2: Hierarchy of authority in the Sailplane class. How technical questions are addressed and disputes resolved.

The initial response to a problem or question is to ask those around, that is older students, in the lab. "[T]he students really don't have problems admitting when they're not sure about things." (S02: l. 355) Quite often this will lead to a general discussion right on the spot among those in the room. Many times the issue could be settled there. For questions relating to implementation of the class design, a student can refer to an archive that contains all student notebooks and presentations from past semesters. With conceptual questions, seniors and lab T/As are convenient resources. The following story is from a freshman:

> Well some of the things that uh [Pipa] explains that I don't get, I I will ask later in lab uh to one of the seniors and they will explain it to me. Um. Like one day we covered stall and where stall will occur, what factors included in stall on a wing and I I didn't get it, but that night at lab, I asked uh .. I believe it was Dave .. Maniaci um just to explain it and he went through he took me over to the marker board, drew these diagrams for me we went through we spent like .. a half hour/45 minutes and after that, I .. I got a pretty good grasp on what stall is. (S05F: l. 343)

An older student added the following, which is revealing of the manner in which this instruction or guidance takes place:

> My seniors didn't expect [us] to know it all, but rather showed us step by step. 'You know the basics, now how can I help you?' (S06: l.625)

Being curious and asking questions in this way was subtly encouraged. S16, a freshman, said:

> If you make a mistake at some point and the senior gets annoyed at you, that happens, too. {uh huh} But there's also if you just sit there and wait for the senior to tell you, "Do this." And tell you exactly how to do it, they might as well have done it themselves (S16: l. 528)

This might not be the most efficient way to build an airplane, but the emphasis here is on learning and teaching/learning requires time and attention.

Should the argument still not be resolved, a student may always write it down and ask the class as a whole for a discussion during a lecture period. In some cases, applications engineers at supply companies or aerospace professors with expertise in a particular area would be consulted for advice.

Several students told of a time when the entire hierarchy of authority came into play. There had been a disagreement over the best method for building the leading edge of the wing of the EZ-build. Clearly, this was a decision of great significance. Should a frame be constructed and then covered with balsa? Or should the contour be shaped using foam blocks that are covered with a fiberglass skin? This account of events follows the story as related by S03. Discussion and presentations to the class did not lead to a consensus. Students were asked to vote on which proposal should be adopted by physically moving to one side of the classroom or the other. The result was a tie! Pipa might have resolved the issue at this point, but he refused to vote. The idea came from the class to have each side build a 3-foot model section of the wing and to document the cost, weight and ease of fabrication. Pipa endorsed this approach to resolving the issue. Formal and informal discussions occurred while this was being done. When the resulting models were presented a month later, the class again voted and a decision was made.

> [O]ne of the best things we have in the class is the chance to get feedback from other students. For them to uh really you know it's like a check and balance type deal. (S03: l. 749)

Pipa occupies the position of authority. It is common knowledge that he has the experience to answer any question or decide any issue. Here is evidence of Pipa's position in the class and his role in the project:

> If we all say,' Pipa, we want to learn about this,' he'll study up on it and he'll give a lecture on it. {yeah} It's happened before. Or if he sees something that we that we need to learn to finish the airplane, he'll lecture about that. (S01: l.87)

> [Pipa] knows what he's talking about. He's doing his doctorate right now and he's a pilot. He worked at an Akafliegen in Germany for a few years. (Which is similar. It's a it's a like a college for building airplanes.) (clear throat) So he's knowledgeable. He's very friendly, he gets along well with everyone. (S01: l. 747)

> He really gives us direction, but then he let's us .. he let's us decide what we'll what we'll do with that direction, you know. He says "this is important, this is important, you should do this, this and this." But, it's up to you to do that. You know what I mean? (S03: l. 653)

> I guess if Pipa gave me an answer, I would take it as the truth, you know? (both laugh) But, if someone else in the class gave me an answer, I would probably .. you know take it for what it's worth, depending you know on the gravity of the situation (S03: l. 719)

> Pipa isn't there during lab, it's just the older students and the younger students trying to figure out on their own what they are doing. (S04: l. 478)

> Pipa teaches to seniors; freshmen can ask seniors for an explanation (S05F, l. 348, 369)

> Pipa provides a comfort zone and reassurance. He is personable and down-to-earth. [A different aerospace professor] would guide them in the right direction, like, how they want it more than what we think is good. With Pipa, we decide what direction to go. (S06: l. 1374)

Thus, Pipa is regarded as a benevolent, but final authority. He is seen to have both the knowledge of aerospace principles and the experience as a pilot. The fact that he is down-to-earth and approachable sets the tone for the relaxed social basis of the activities. The fact that he has designed, built and flown sailplanes puts him in a position of authority regarding practical technical matters. As a PhD student in the Aerospace Engineering Department, he is knowledgeable of the theoretical issues. Finally, since he participated in an Akaflieg in his native Germany, he knows about how the program should run and can be trusted to keep the project(s) moving forward. The presence of such an authority on every aspect of the project is reassuring to the students. Pipa's role in the project is unique among project-based programs on campus and goes a long way toward accounting for the tenor and scope of the Sailplane project as it exists in 2005.

Code words

Certain terms occurring in the interviews appear to have acquired idiosyncratic meanings or usage in the context of Sailplane. These words might be found repeatedly in a single interview or they might appear across the interviews. Though a narrative analysis is beyond my expertise, I focus on the most common of those "code words" in this section in order that the reader will not miss the connotations they carry when encountered in the accompanying quotes. The common occurrence of the word "intimidating" in the meaning of "overwhelming" (without the connotation of a physical threat) is an example of such a code word that has been treated elsewhere in this paper.

Joking or joking around

While the usage of the word 'joke' conforms to the first dictionary definition as "something said or done to provoke laughter" (Gove, 1967), in the context of Sailplane, the term occurred often and seemed to carry a further connotation. If one can 'joke around' with a person or group, it meant one has reached a level of acceptance by that person or group. Those who do not 'joke' are seen to be outsiders, usually because they do not work well with other people. It seemed that a person came to know if (s)he was accepted in the group by whether (s)he could 'joke' with those higher in the social hierarchy. In addition, 'joking around' was emblematic of the relaxed atmosphere in the Sailplane lab and class. It was important to the students to know that it was okay to 'joke around'. They saw this as an important difference between Sailplane and their other classes and a contributing factor to why learning was fun in Sailplane.

> The class is a very social atmosphere. We joke around and eat and things like that. (S01: l. 508)
>
> It didn't take too long to sort of you know … get uh accepted and be one of the you know be joking around like everyone else."(S02: l. 180)
>
> [The person who wishes to work alone] will usually just have like y'know a couple of friends in the class and you know they'll uh get along with them, but then won't be that person that is standing on a chair .. telling jokes (S02: l. 1238)
>
> Through lab, I've been able ta .. you know really you know joke 'n get to know people. {yeah} It 's it's a lot more relaxed in in lab, I think. (S05: l. 358)
>
> The less a person you know jokes and all that stuff, my grading system, I guess you would say would be like you know the lower year they are. (S05: l. 634)
>
> …they know [Pipa]better than I do and if they can joke with him, then I see that he's a fun guy. (S05: l. 666)
>
> I do believe I'm fitting in. Um I make lots of jokes with the seniors; they make lots of jokes with me, so y'know that that's how I gauge if uh I'm fitting in is just how much and like the severity of the jokes, I guess you would say, we have with each other. (S05F: l. 51)

Know-it-all

The know-it-all is one who attempts to demand status or respect in the class based on outside experience with building Sailplanes. The trouble with know-it-alls is that they tend to misjudge the importance of the social norms of the class and to undervalue the collaborative work that has occurred and which informs the vehicle design. S01 returned to this concept eight times during the interview!

> I think I do have more real-world experience with airplanes than .. almost everyone in the class. There's a few that fly more than me, but not too many. {uh huh} And I think I am the only one who is building an airplane outside of class and has built an airplane that's flown. …But still, like when I first came into the class, I was like the stupid know-it-all Physics major who's not even in the major. I think people resented that (S01: l. 362)

> There's one kid that they seem to knock down. {laughs} That's 'cause he's like a little *over*enthusiastic. Tries to make himself out to be a know-it-all. {Huh} Which kind of annoys everyone. (S13, l. 1376)

> She kind of thought she knew everything, like how to do it. And she didn't. So, she would do stuff without asking and then it would totally mess up and we would have to completely redo it. .. It wasn't just that it was her last semester. It was a personality problem, too. {uh huh} Like she got mad one night and just left for like a month and a half and decided to work by herself. {Oh!} Well you can't really work by yourself in a class that's oriented around groups. (S11: l. 958)

Politics

The term 'politics' has nothing to do with governance. Instead, 'politics' refers to the social interactions that are necessary to build consensus. These social interactions are seen to sometimes be an obstacle to efficient technical work. Politics implies that people skills are needed to convince someone of an idea that should be clear based on the technical merits of the situation alone. Politics was a particular obsession of S01. He referred to it extensively on five occasions. Others referred to this social dynamic having an effect on the technical outcome of the project, but did not use the specific term.

Mostly, I include it here because it illuminates the term social-political, or sociopolitical that is a found term that I use in this paper.

> It's got, yeah, a little bit of politics, a little bit of he-said-see-shed he-said-she-said and things like that. Lots of interactions 'n I kind of like that about it, because it's not just equations and things.(S01: l.174)

> To me, it means that people … .instead of arguing for a way to build the airplane, they are arguing against someone else. It turns into a personal thing as opposed to a technological thing. {uh huh} To me, that's what politics is in the class. (S01: l. 808)

> That's where the like the social-political aspect certainly comes in {laughs} like … who do the freshmen like more, you know? That's who they're going to choose, unfortunately, because you know they can't tell what method is going to be better" (S14 l. 960., confirmed by S04)

Status in the class

The students do not talk about "status" in the classroom, but there is evidence of a well-defined , that is agreed-upon, hierarchy of respect. Not only is there agreement on who ranks where, but also what goes along with that rank and how to move up. Elsewhere, we have described how the freshmen, sophomore/juniors and seniors experience Sailplane. Here, we discuss the hierarchy of status and how promotion occurs.

With rank comes not really power, but responsibility. The term "freshman" here generally refers to a person who is just joining the class, whether as a bona fide freshmen or as a sophomore or even a junior. At the time of these interviews, there were enrollment restrictions. Since new students require so much training over time, most of the new members were freshmen. A "freshman", then is one who is new and who doesn't "know anything."

> [The seniors] understand you're a freshman and they understand that you don't know anything. So, it's almost kind of like a I guess you'd say mentoring program within the class because they teach you as you go. (S04: l. 174)

> You *can't* understand this stuff as a freshman. (S08: l. 325) You don't have the math. But you can sit down and help. 'Read me the numbers so I can put them in' (S08: l. 334)

The various roles in the class provide the context for the team dynamics. While anyone can be a 'friend' – and most are! – a student's status in the project defines the expectations placed on that student. Students of all levels 'joke around' with each other, but status level determines if one's ideas and one's hands-on work will be trusted. Whether one is an asker of questions or an answerer of questions demonstrates one's position in the project. As S06 said, " [In the year ahead] I'll probably be consulted, too, instead of just being told what to do." (S06: l. 1968)

Table 5-3: Levels of status and the means for upward mobility.

Status level	Behavior that helps increase status	Source
Freshman	Be curious; ask questions; stay after to talk to Pipa; help out in lab as able. When they gain the trust of their team leader (that is, when they can be assigned tasks to do on their own), they can move up.	S03, S04, S05, S09, S14, S16
Team member	Can answer some technical questions, assigned work is completed reliably; must be able to express opinions in class discussions and presentations. When they "are seen" to do a lot of work and be the source of ideas that the class adopts, they can move up.	S03, S06, S07, S13, S14
Team leader	Based on experience in the class, not class status; confirmed by Pipa. Leaders take on responsibility to advance the team work and to train new students in	S01, S02, S03, S11, S14, S16

	technical areas.	
Senior	Based on class standing and longevity in the program. Seniors take responsibility for the overall direction of the project by leading discussion and guiding the class toward decisions. They are responsible for passing on their knowledge so the project can continue after they leave. They train and confirm the younger students. They do work, but also help others.	S01, S03, S05, S06, S08, S10, S11, S14, S16
T/A	Selected based on technical competence and teaching ability, the T/As are responsible for the safe operation of the labs. Often, but not always grad students, they have usually been associated with the class in some way for a long time. T/As are above the fray. They are not a part of any lab team. They answer questions, teach fabrication skills when needed, but defer to the seniors in terms of what activities occur, by whom and when. They do less work than seniors, but are present as an authority when Pipa is not.	S08, S10, S12, S14
Alumnus	Friendship persists after the class – a useful resource for graduating seniors. A network of former Sailplane students has NOT emerged.	S08, S11, S14, A15

The primary currency for promotion is length of service and level of experience gained in the Sailplane class. Status is not necessarily correlated to class or age and it definitely does not relate to experience with building sailplanes. Two respondents related the tale of a student who had extensive experience building and flying sailplanes who joined the program as a senior. This senior expected that his experience would be valued. It was not. The sailplane students were suspicious. How could this person know that his answers applied to the class designs if he had not been in the class when the design was created? .

> We almost breed our own way of thinking …[students who join as] seniors don't get it. Freshmen and sophomores are more inquisitive. You learn to question. Freshmen and sophomores learn that it is okay to not know what is going on. It

> is not a sign of weakness. [In this course,] you will be continually learning. *I* am learning from the freshmen. They bring fresh ideas.[13]

It is evident that sailplane students truly enjoy each other's company. They are respectful of each other at all levels. With status comes not power, but influence in the class. There seems to be room for everybody at the top. Table 3 summarizes the status levels that I observed along with behaviors that indicate competency for the next level. It is seniors and ultimately Pipa who confirm that a student has reached a new level of competence. Figure 5-1 depicts this information in more detail in graphical form.

[13] Wheeler, T. 2003. Draft Sailplane assessment results, p. 4

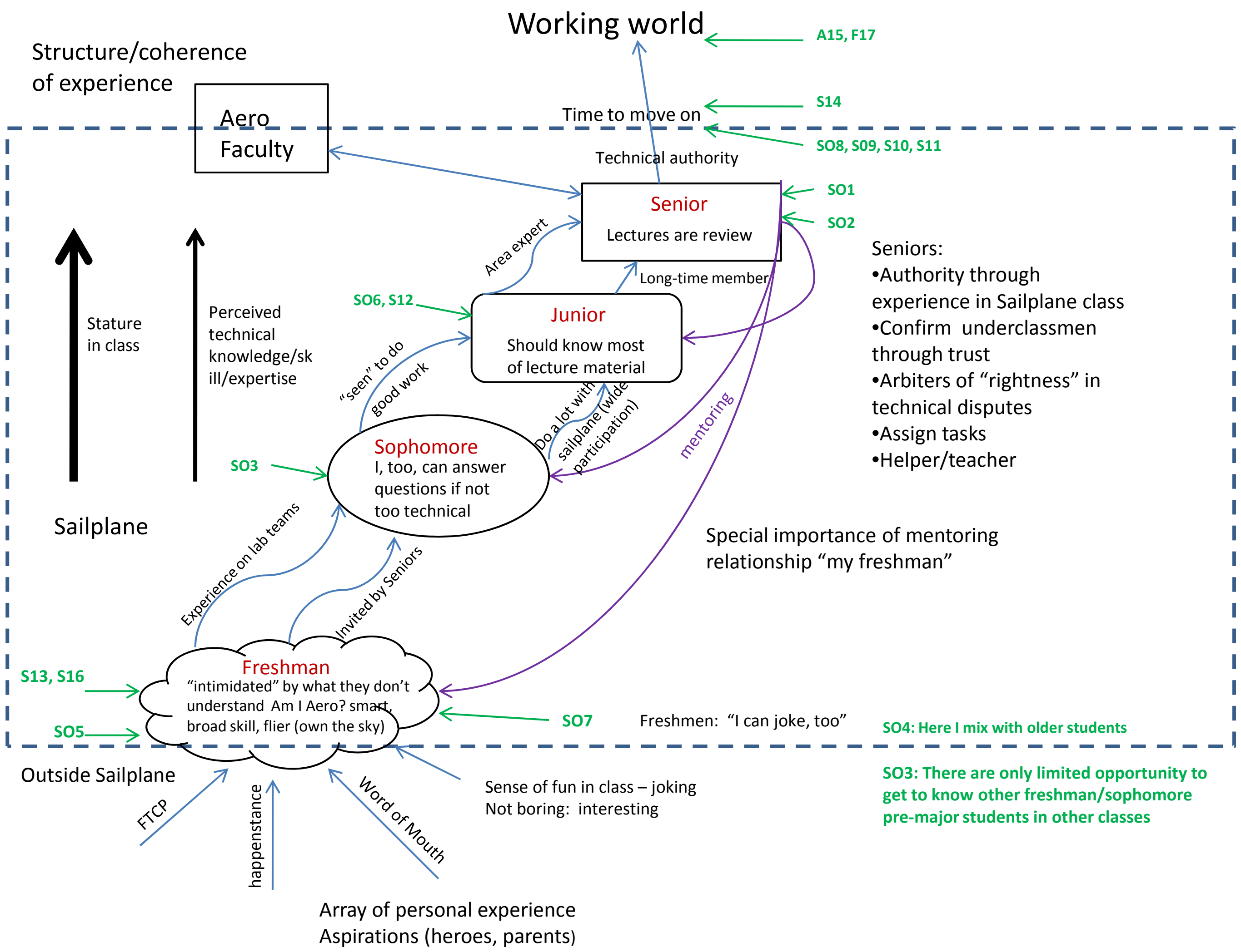

Figure 5-1: The structure of the status hierarchy is social in nature. The mechanism for social advancement (or not) is experience, trust or technical knowledge/skill.

Grades and grading

Generally in a highly competitive engineering curriculum, students are loathe to take risks or make mistakes for fear of paying the price of a lower GPA. But in Sailplane, a student is expected to learn through making mistakes. The class grade is based on peer evaluation, presentation performance and a final report. This puts the emphasis on visible team work. This method is not uniformly embraced. Here are three perspectives on how the grading system works in Sailplane. The first was the predominant view.

> The course grade is based on your peer evaluations. They're most important. And teacher evaluations and um the commitment that you have… Your peer evaluations are very important, which means that you have to be an effective team member. You have to help; you have to communicate properly. You have to be there and make sure that the project is going smoothly because if you are no help at all [to your team], your grade will reflect that, because the peer evaluations are so important. So, it's not a really big concern for me, because I've done well in past years and I have more experience now, so I can help more. And I'll be there on lab nights, because I made that commitment. So, and um the presentations, I'm pretty comfortable speaking in front of the group now, so I mean that's pretty good. And then, um, we can all help each other on the report that we have to produce at the end of the year, so um that hopefully will go into having a good grade. (Transcript S06, lines 1731 - 1751)

> Well, I did I received a B once and an A- once in Sailplane and yet on the current airplane, 35% of it is .. my design. And it's significantly more than any other person in the class and it's just like I think for me, like being a kind of a higher end student, like if I put in the same amount of hours and the same amount of productivity, it wasn't always good enough in the eyes of the instructor" (Transcript S14, lines 63 – 71) "In a normal class, you have homeworks, you have quizzes and exams and maybe a project. And that's what you're graded off of. And in Sailplane, like you have to get a grade somehow, so like you do have your lab notebooks, and some design presentations and design reports or lab reports. {uh huh} But, there's not really any solid metric to be guided off of , so there's not an indication of how many hours someone put into a certain component and like whether or not, those hours were effective hours That's really what made a difficult for me, I think. (Transcript S14, lines 43-55)

> What happened to me when as a team leader, I kind of went off on my own and re-designed the thing. [Those who go off and do significant work on their own], their grades wouldn't necessarily reflect what they've contributed. And I think you know, engineers being super-competitive, when you get a B, like most of them would be like, "Why would I be in the class again?" (Transcript S14, lines 1314-1323)

Thus, grading serves a different purpose in Sailplane than in other classes. Here, it is not simply the impersonal quantification of performance on tests and quizzes. Rather, it is a quite personal measure of how students are fulfilling the expectations of peers and, particularly, Pipa.

> It's not, I wouldn't say, like in a lot of my classes, the sort of in a boring class, the motivating factor is to get an A in the class. But in this class, that isn't the motivating factor at all. It's um .. You're motivated because it's fun and you want to learn about it. {uh huh} And you like being with the people and everything and groups and … (S02: l. 1327)

As we saw above in the quote from S14, the disparity between how grading is used in Sailplane and how students generally understand the meaning of an A,B or C can cause confusion. A 'B' that is delivered in Sailplane in order to encourage, say, better team behavior in the Sailplane lab, might have an outsized effect on a GPA and a long term effect on the prospects of these honors students. The Akaflieg organizations, upon which the Sailplane program is based, are not a part of the academic programs of the German universities with which they are associated. Submitting to a grade is a cost of having Sailplane be a part of the curriculum. At the same time, the grading function imparts to the Sailplane class the conventional power structure of a classroom. Beyond his technical expertise, it conveys to Pipa the final authority in running the class. He is the one to confirm the students' efforts. It is not clear how such leadership is established in the German model. In addition, by being a class, Sailplane becomes a sanctioned activity of the Aerospace Engineering Department. It can command resources, facilities and legitimacy that would not otherwise be possible. It is thus acceptable for Sailplane to assume a central role in the educational program of these students.

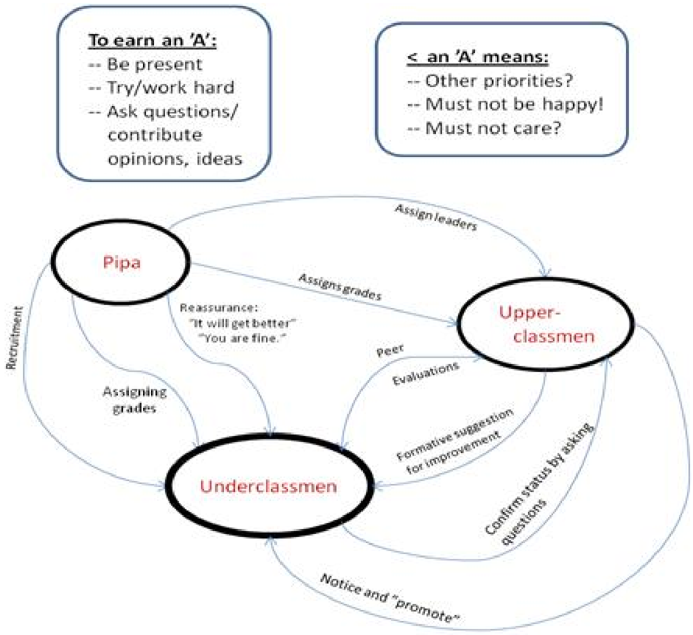

Figure 5-2: Concept map of the grading relationships in Sailplane

Chapter 6 Discussion of the data

From the stories and information cited in the previous chapter, it is evident that the structure of the Sailplane class supports development along three distinct dimensions: academic development, professional development and "sociopolitical" dynamics (See Figure 6-1) . These three dimensions become intertwined in the minds of the respondents. In the quotes that follow, the emphases have been added to show how concepts and expressions appropriate to the dimensions of professional work, academic environment and sociopolitical dynamics are all used to describe the Sailplane experience:

Figure 6-1: Three dimensions of the Sailplane experience

> Yes, I think [Sailplane] is successful in what it does. I look at the people coming out of it and I see that it appears to me that they are *better people*. They know how to work in the groups, and they *know how to work in the lab* and .. they have some *understanding of things*. Little better, maybe. (S16, l.1349) (Emphasis added.)

> I really *like the people,* I mean..{yeah} One of my *best friends is the T/A* for the class and things like that. Um..but I still it's still *I just like building airplanes* and *it's a fun course*. (S01: l.276)

> Instead of arguing for a for a way to build the airplane, they are arguing against someone else. It turns into a *personal thing as opposed to a technological thing*." (S01: l. 808)

> Will I be accepted? they'll *accept me* if I'm *just a learner* and I want to *get into this field more*? (S06: l. 423) … I like it that I am given *responsibility*, even at *my level of knowledge*. (S06: l.630)

> [Y]ou sorta [SIC] I guess weed out the people who don't want to be engineers. I mean if you're not having fun working with other people working on the sailplane .. (S12: l.664)

> … it's not just engineering work, it's *engineering work mixed in with a little bit o' like social politics*, I guess. And, you just have to *learn it through hands-on* experience. (S14, l.723)

> Because we were always doing things together, uh it helped me personally, because I was able to sort of pick up you know things about other courses that I was taking, *help with my homework*, those kinds of things. And at the same time, we were having *fun*. I mean, it wasn't all work, it you know, a lot of it was play. And so, I thought, "Well, you know, yes, this is hard, but if this is what it's going to be like working in the *aerospace field*, I you know maybe want to pursue more of this and see how far I can go." (A15: l. 239)

The social relationships built while doing hands-on work in the lab (See Figure 6-2) carry over to become important personal friendships and so become useful in this and other aerospace classes. Professional skills (teaming and professional presentations, for instance) are used to advance the academic agenda. The students are building a sailplane, yet "We are not a production line" (S08: l. 585). Rather, they are "learning how to learn" (S03: l. 693), an academic pursuit. The freshmen value their friendships with the seniors, not only because they have common interests, but also because the seniors help them learn aerospace principles. In Sailplane, if a freshman performs poorly, he disappoints "his" senior. If he does well, that senior is close by to confirm his accomplishment and to give him

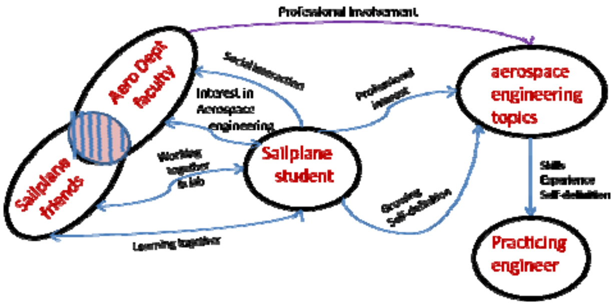

Figure 6-2: A concept map of the relationships that students build in Sailplane

increased responsibility as a result. She (the senior) is also available to provide guidance on fabrication skills or to explain difficult engineering principles.

The project around which the class is organized is an ambitious professional undertaking, but the students' job is to learn and subsequently to teach – clearly academic pursuits. The particular balance of these three elements is a defining characteristic of Sailplane.

Another defining characteristic is the position of benevolent authority held by Pipa. Mark Maughmer, co-founder of Sailplane, was emphatic (in personal conversation) that the leader of Sailplane must have authoritative knowledge. Pipa sets the tone of the class. Interestingly, though, Pipa is not regarded as the sole source of learning. He is merely one of many sources. The students looked to Pipa to *support* their learning, not necessarily to direct it:

> If lectures are good, it's better it helps, but say if there's if there wasn't very good lectures for a few weeks or something or, you know, it's not like learning stops. There's still plenty of other aspects of the class since it's so group based {uh huh} And um…and there's the the older students that can still pass down a lot of knowledge to the younger students and the older students by that point are usually pretty motivated to learn by themselves also. (S02: l. 1254)

This is in stark contrast with the typical classroom, where the professor *is* viewed as the sole source of learning, responsible for choosing what is to be taught and how.

The Sailplane class is a learning community with a hierarchy of authority (See "Status" section, Chapter 4), rules for behavior (see "Traits for success") and commonly constructed culture. The culture is comprised of code words and phrases, as well as stories of important historical events. Just as there is a physical archive of the technical experience (a record of notebooks and presentations from past semesters is available to the students), so do oral stories make the social history of the project available for the current participants. When I asked each student to tell me a story of an important event in the history of the class, I got an interesting range of responses. Most related an event of import to themselves (such as the egg-drop contest when they worked closely with a senior to build a glider). Some told of a particular event in the life of the class (such as the story of the senior who did not fit in, or the story of laying up the wing spar, which took many people a long night of work in a party-like atmosphere to complete). One story I found particularly touching told of a party at the apartment of a Sailplane senior. A socially inept underclassman was observed to be "joking around" at the party in a way that made it clear that he was now accepted as one of the team.

Not everyone thrives in the Sailplane class, of course. One of the keys to the cohesion of the class is that those who are not comfortable in this particular social environment do not stay long. Those who leave were generally students who cannot accept the social rules, who have a weak interest in aerospace engineering or who establish social ties elsewhere. Some were uncomfortable working in the lab groups or could not afford the time demands. It would be difficult to be a part-time Sailplane student.

The social mores of the class are enforced formally (through grading, that is academic means) and informally (through mistrust, that is professional disregard). I would call this a 'weak' conclusion because my data points, though consistent, are few. However, those who did come back semester after semester felt an elevated loyalty to the program and to the people in it. For this reason, it is not surprising that non-Sailplane students tend to view the Sailplane participants as “clique-y”. Sailplane students feel that they are a part of something special.

The storyline (See Chapter 4 for an extensive description of the “typical” experience of Sailplane) is a commonly constructed and oft-repeated account of the path of experience through the Sailplane project. It provides a paradigm for social interaction. Even though the task of building a flight vehicle is highly technical, many students indicated that an ability to work well with others (a social skill) is one of the few pre-requisites for success in the class. Explicit in the storyline are roles that students are expected to play. These roles were seldom questioned and became markers in the landscape by which students gauge their progress. Students go from ‘freshmen’ (by which is meant first-year students, even if they are juniors) to team members to team leaders to seniors (who sometimes are juniors and sometimes are super-seniors). Freshmen who show promise are those who ‘ask questions’. When those freshmen ‘gain the trust’ of seniors, they are given more responsibility. In order to progress to a leadership role, the quality of a student’s work must be visible to the class as a whole. It is important for students to make their opinions known and to be acknowledged as the source of the ideas that are carried out by the class. Based on a public record of accomplishment, team members are appointed team leaders by Pipa. In this way, they achieve the status of ‘senior’ in the class parlance.

Having reached a position of status, a student may perform one of two functions. (S)he might take responsibility for a portion of the project. Alternatively, the (s)he might play a mentoring role, taking responsibility for teaching the freshmen. Some seniors fulfill both of these roles. Nevertheless, seniors generally come to be regarded predominantly as one or the other: a technical resource or a teacher. In my judgment, S01, S02, S09, S14, and A15 were seniors (or higher) of stature due to their technical work, who were pushing (or had pushed) to complete tasks with which they had been associated during their Sailplane career. Three others were identified as technical leaders by respondents, but were not in the pool of interviewees. Respondents who presented themselves primarily as teachers included S07, S08, S11 and the three lab T/As. One additional 'teacher' was not interviewed. It is perhaps significant that three of this latter group were women, while none of the former group is female. In my judgment, the more ambitious students chose the former path, but roughly equal numbers seemed to go each way. Both competencies are valued in the project.

The learning environment in Sailplane is forgiving. Students are encouraged to explore and to try new things. Mistakes, caught by the class or the team leaders and corrected, are treated as constructive experiences toward deeper understanding. Grading is based on peer evaluation of student effort and on class presentations.

While the student respondents agreed that they were learning a lot, there was less agreement on precisely *what* was learned and how it would help them in their subsequent careers. They felt they were gaining hands-on experience of abstract concepts. Many students cited the professional skills, such as presentations, working in groups and planning, as important skills that they were learning in the program. Undeniably, Sailplane students learn skills that are central to building flight vehicles, such as how to lay fiberglass. Some learn machining and welding skills. They get experience with handling design tradeoffs. They also gain confidence in their ability to work through the inevitable fabrication surprises. One freshman noted that he liked working on Sailplane, not because *he* would be laying fiberglass in his career, but because the Sailplane experience will help him to direct others who do. Having built a support spar or a leading edge for a wing in the Sailplane lab, he reasoned, he would be able to design better wings himself. Perhaps it is this conviction that underlies the confidence that the Sailplane students take with them.

The advantages that the students attribute to their Sailplane experience would be difficult to quantify. They are not uniformly related to any particular competency. The skills that the students cite ("hands-on experience", "presentation skill", "working with people") are expressed in general terms. Unlike with core curriculum courses, it is difficult to point to any specific subject matter that Sailplane students learn.

Subsequent events have revealed that the fall/spring 2005 was a turning point in the history of the Sailplane class. A particularly large cohort of seniors graduated in that period and Pipa himself completed his PhD and moved from Penn State. What the students could not know was that the focus of the class would subsequently turn from sailplanes to human-powered flight vehicles. The course would again be taught by Dr. Maughmer, as it was at its inception. For this reason, this study is valuable as documentation of the Sailplane class as it was in 2005. It should be evident from these student voices, just how much they valued the experience and how important they felt this class had been to their development as practicing aerospace engineers.

Chapter 7 Conclusions

If we seek to understand the student experience of a project-based course such as the Sailplane class at Penn State University, then the first-hand account of student participants should be a central part of the analysis. In response to a semi-structured interview, a broad cross-section of the Sailplane class population described the program as a “laid-back” learning environment where students nonetheless are engaged in the challenging and highly technical task of building a full-scale flight vehicle.

In Sailplane, the students feel fully engaged in the learning process. They use their eyes and hands as well as their ears to perform class duties. They must learn difficult aerospace principles (academic dimension) and fabrication skills (professional skills). Yet they consistently cite the “ability to work well with people” as the key to success in the class (sociopolitical dimension). Learning is fun, not work. This is in contrast to their experiences in lecture classes, where only the academic dimension is experienced. The students described those classes as “boring” or “impersonal”. The hands-on experiences provide both an intuitive understanding of the abstract concepts *and* important professional skills. Sailplane is not “just” a class because the task of building a sailplane requires a sustained effort and expert skill. Nor is Sailplane a strictly professional environment. Rather, it is organized as a learning community, where student learning is given priority over production deadlines. It is not a club, either, though the interactions and activities can resemble a club atmosphere. Sailplane is all three of these things together. As we saw in Chapter 3, Sailplane is in line with modern educational theories of how college students develop and how they learn. Sailplane is an active environment that equips students to perform expert behaviors and encourages them to see their careers as a constant learning activity.

The students felt well-supported in the tasks of learning and of building a sailplane. When they needed help with Sailplane work (or class material or broader academic issues), they felt comfortable asking the senior members of their teams, lab T/As or Pipa. Technical decisions pertaining to the design or build were handled in a cooperative manner by whomever happened to be present. Issues that could not be resolved informally, would be referred to the class as a whole to discuss. In such cases, Pipa would moderate the discussion in the manner of an academic debate, not a production decision.

In the final analysis, the Sailplane project provides a rich set of positive experiences and associations. It reinforces the students' enthusiasm for aerospace engineering and imbues in them the confidence to meet any challenge. Sailplane students see themselves as expert learners. The program is a success because the learning settings (academic, professional and social) reinforce each other. It is structured as a class, but there is no fixed syllabus. One clear measure of success is the enthusiasm that the participants so clearly expressed in these interviews. They felt in command of their project work and fully engaged in their education. This sense of total involvement is seldom encountered in other engineering classes.

For the students who put in countless hours on Sailplane work over four or five years, Sailplane was fundamental to their development. The structure of the class (multi-semester in length, vertical integration of the lab- and design teams) made this so. These students internalized aerospace engineering and were personally committed to the Aerospace Engineering major at a very early stage in their university careers. Aerospace engineering became a part of their personality. They spoke as comfortably to each other about ailerons, the empennage and drag coefficients as they did about weekend plans. Even students who were no longer Sailplane members expressed a certain wistfulness and a respect for the goals of the class.

The influence of Sailplane on the Aerospace Engineering Department extends beyond its effect on individual students. The class attracts excellent students to the discipline, forms a standard of excellence and provides an avenue for the best students to demonstrate accomplishment. Because of its subject matter and legacy tracing back to the Akafliegs, Sailplane is highly specific to and emblematic of aerospace engineering as a whole. Sailplane shows what the study of aerospace engineering can be and what the work environment surrounding the fabrication of a flight vehicle might be. The students find it endlessly exciting. The Head of the Aerospace Engineering Department, Dr. George Lesieutre said,

> Sailplane students can [take the course] semester after semester after semester in a kind of integrative activity over time. I think it tends to mark them in a way. There's a pretty great esprit d' corp in there. (F17, l. 451)

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Appendix A

Interview Protocol

(18 September 2005)

Opening Comment

I will be asking you questions, but what I really want is your story. What do you feel are the important moments in your Sailplane experience and in what ways are they meaningful. It is my hope that these interviews will yield an aggregate picture of the 'value' or the 'meaning' of Sailplane in the personal and professional lives of the Sailplane students. Since it is your story, please feel free to direct the conversation toward the elements that you feel are important.

Definitions: **Project-based course:** A Project-based course (PBC) is a credit-bearing course in which students encounter discipline-specific subject matter through collaborative team work on a complex, technically challenging project.

General (starter) questions

1. What is the status of the project as the semester begins?
2. What will be the focus of project work this semester?
3. Have you flown on or worked on a sailplane before joining this course?
4. How many hours/ week do you spend on Sailplane projects?
5. In your own words, what is the purpose of the Sailplane Project?
6. What aspects of Sailplane do you mention when talking to students you know who might be interested in joining? Would you recommend Sailplane to a senior? To a freshman?
7. Would you characterize this course as "hard"?

Reasons for joining

Expectations

8. Think back to your first experience with Sailplane. What was it like?
9. How did you hear about the Sailplane project?
10. What caught your ear and led you to consider joining?
11. What were your initial impressions after your first day?
12. What reservations did you have after that first day?
13. What did you expect to gain for your work on the Sailplane Project?

14. How does your present experience with Sailplane compare to your initial perceptions?
15. What has motivated you to continue with the program?
16. Please list the benefits to you now of participating in the program?
17. What is the role of Sailplane in your work toward a degree?
18. What is the role of Sailplane in preparing you to be an Aerospace Engineer?
19. What is the role of Sailplane in preparing you for your next professional step?
20. What has been the impact of Sailplane on your GPA?
21. In what ways has your educational experience at Penn State exceeded (or not to lived up to) your expectations?
22. What has been the impact of Sailplane on your more general college experience?
23. In what ways do you hope your studies at Penn State will improve or prepare you?

Learning environment (standardized format) Time: 20 min

24. Walk me through a typical lab period …
25. What do you like about working in a project-based course? What do you dislike?
26. In order to help me understand what Sailplane means to you, can you cite for me an environment that you have been in that was similar to Sailplane or which prepared you for what you are encountering in Sailplane?
27. There is certainly a body of theoretical and practical knowledge one must have in order to build a sailplane. Can you list *all* the ways you learn that material?

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28. Think of a task that you successfully completed for Sailplane. What were the steps you took?
29. Now, think of a task you completed in a lab course. What steps did you take to solve that problem? How do you account for the differences?
30. Think of a task that you successfully completed in your work experience (Co-op, summer internship, non-technical job) How was your approach in that instance different from your approach in Sailplane? How do you account for the differences?

****

31. In what ways do you think the work environment in the Project is similar to a professional work environment? In what ways different?
32. What structures of responsibility exist in the project?
33. Please describe the organizational structures of the (Sailplane) course. How does the degree of structure in the course affect you positively or negatively?
34. What is the philosophy behind the teaching method of Sailplane from your viewpoint? In what ways is this teaching philosophy important to the project work?

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35. How important is the quality of instruction to the fulfillment of Project goals?
36. What qualities do Pipa possess that are important to project success?
37. What are the core features that bind this organization?
38. How important is *what* you learn (subject matter) to your participation on the project?
39. What factors *are* important to your continued participation?

40. What role does the course grade play?
41. What is the ideal size for a class like Sailplane? How important is class size to you?
42. What do you hope to get out of Sailplane *this semester*?

Socialization

43. Please list for me all the groups you are a member of in Sailplane. How would you characterize your participation in each?
44. What personal qualities help students succeed in Sailplane? [**OR**: When a new person walks into the room, what qualities do you look for?]
45. What primary personal quality do *you* bring to Sailplane?
46. What benefits (of working on Sailplane) are social and what relate to personal development?

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47. Are there cultural elements of the Sailplane project that you felt you had to learn in order to be a 'full' member of the project? Can you give me an example of an in-joke or story that is part of the Sailplane culture?
48. Please describe how a new person becomes acculturated to the project.
49. Were there mechanisms built into the project to help you be accepted into the group?
50. In your own experience, take me back to a moment when you really felt you had become a member of Sailplane.
51. Do you think it is important for 'senior' members to reach out to newcomers?

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52. What role does Pipa play in the social dimension of the project?
53. What reasons can you cite for people leaving the project?
54. Do you know of some who did not continue with Sailplane because of *social* factors?

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55. What effect has the Sailplane Project had on your personal life?
56. Tell me about a time when you felt particularly excited about your participation in Sailplane.
57. How does progress in the project (macro) affect your personal attitude (micro)?
58. How do outside conditions (such as the job market or war in Iraq) influence your studies?

Relationships

59. On a continuum from 'purposeful' to 'casual', how would you characterize the relationships you form in Sailplane?
60. In what ways do you relate differently to students in Sailplane than to students in other courses you are taking? T/As?
61. Do you relate to Pipa differently than to other Aero faculty? Is this relationship significant to the course? To you?
62. How do you anticipate social interactions in a professional setting will be the same as or differ from what you are used to in Sailplane?

63. Are there differences you can point to between how you relate to people in Sailplane in a work setting as opposed to a casual setting?

Teaming

64. What role does teamwork play in Sailplane work?
65. Do you prefer working on a team? Or independent work? What personal traits account for this preference?
66. How would you characterize your present role in the project?

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67. On a scale of 1-10, with 10 meaning 'very important', how important is it that Sailplane students have a high degree of:

    Reflective judgment

    [This means the tendency to think things through logically and to come up with a right answer. The opposite of reflective judgment might be "enthusiasm" as the driver of a person's efforts.]

    Technical knowledge

    Hands-on facility

    Intellectual curiosity

    [This is subtly different from creativity (below). The intellectually curious person say, "Given X, I wonder what would happen if Y…" or "Hmm. That works better than I thought. I wonder why?" The creative person is one who is not constrained by conventional patterns of thought in his/her approach to problem solving.]

    Teamwork skill

    Creativity

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68. In what ways has working on Sailplane improved your teamworking skill?
69. What techniques are used to mitigate the problem of slackers?
70. In what ways do students have a say in the direction of the project?
71. In the hypothetical situation of a student who would prefer to work on his own, how would the project organization accommodate this preference?

Discipline

72. Think of an example of the following behaviors that you might have observed in a Sailplane setting:
    Poor team dynamics
    Wrong, substandard or late individual work
    Anti-social behavior
73. How did they affect the project?
74. How would they be handled and by whom?
75. What was the outcome of the example you are thinking of?

Transforming experience

76. Thinking back over your Sailplane experience, can you point to an incident that was particularly meaningful or fun or symbolic for you?
77. Tell me a story from your first year in the project that typified your 'first year' experience.
78. Can you cite an incident from your second year on the project that shows how you had grown in the project?
79. Predictably, I am looking for an event from your third year that is revealing (or typical) in some way that you can point to.
80. …OR Tell me about a time when your work or your participation in Sailplane touched the things you value deeply about yourself.
81. …OR Tell me the story of an incident that changed you in some way that you can point to.

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82. Tell me the story of an incident you observed that was significant for those involved.

Evidence of growth

[Note: I am finding that these questions largely get answered in the course of answering the questions that have come before. If so, skip this section.]

83. What differences can you point to that distinguish Sailplane students from Aerospace Eng students you know who have not participated in Sailplane?
84. What distinguishes long-time members from new students?
85. How has your attitude toward learning Aerospace Engineering changed over the years? What role has Sailplane played in this change?
86. How do you anticipate that your Sailplane work will impact your career?
87. What new directions have you embarked on as a result of your experience on Sailplane?
88. What about the course helps you prepare for an engineering career?
89. How do you feel yourself different from the person you were one year ago? Three years ago?
90. When this project is over, what will you take away?
91. How does Sailplane relate to what you see yourself doing 5 years from now?

Outcomes

92. In what ways is the Sailplane project 'successful' in your view?
93. Do you feel well-prepared to assume the role of engineer? What has been the affect of Sailplane on that perception?

94. Evaluate the impact of Sailplane on your technical skill.
95. Has your work on Sailplane confirmed your sense of your own strengths and weaknesses? Has it led you in new directions?
96. What has been your influence on the project?
97. If you could change something about the project, what would it be?

Final Questions:

Demographic questions:

1. What are your immediate professional goals?
2. What are your personal aspirations for the next 5 or 10 years?
3. What factors in Sailplane heighten your preparation for the next phase of your career?

Final questions:

4. Is there anything that we talked about today that you would like to change or delete?
5. Do you think I have a good sense of what participation in Sailplane has meant to you?
6. What questions *should* have I asked in order to understand your PBC experience?
7. Is there anything you would like to add?

Additional questions for SPIRIT students:

1. Describe Sailplane in your own words.
2. What about Sailplane appeals to you? Where do you feel it falls short?
3. What were your reasons for NOT joining Sailplane?

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4. What is the difference between the experiences of people you know who are in Sailplane and your experience in SPIRIT?
5. What are the differences between Sailplane and SPIRIT that affect the way you learn in each? **OR:** How does what you learn in SPIRIT differ from what you learn in Sailplane?
6. How *should* one choose between participating in SPIRIT or Sailplane? What would be your advice to one who could not do both?

One-Shot question:

[The purpose of the one-shot question is to be prepared if all goes wrong and we are about to lose the respondent. An answer to this question alone would provide useful data.]

Having participated in Sailplane, what will you take away from it that will make a difference to you in your future?

As I set out to describe Sailplane, what aspects of the project should I make sure to mention that set it apart?

Appendix B

Transcripting Conventions

Orig Date: 30 Mar 2006

Transcripting was completed by me alone. By the end, I had gotten the process down to 6 minutes of transcripting for 1 minute of interview (10 minutes of interview per hour of transcripting). I used a transcripting pedal and 'Wave Pedal' software to control the pace of the playback of the .msv digital audio file. The files were stored in .rtf format for easy importation into NVivo. Word numbered the lines for reference (but NVivo did not import the numbers. NVivo keeps track of location through paragraph number.) I felt it was important to indicate pauses. As an interviewer, I felt it important to not interrupt pauses.

I tried to render the verbal conversation literally as it occurred. Verbal sentence structure, of course, differs from written sentence structure. I tried to use written conventions to indicate the verbal structure. This required me to broaden the meaning of some written symbols. For instance, these respondents would casually string together many thoughts and connect them with the word 'and' as below:

Example 1:

> S11: Yeah. I think so. It was. And at the time, there weren't as many females. There are quite a few now. {uh huh} There weren't when we started. And that was somewhat intimidating, too. And there were a lot of bigger guys! (laughing) Which was also kind of just .. physically intimidating {yeah}.

I tried to indicate the end of a thought using a period, even if the respondent continued with an 'and'. I picked up clues about where a thought ended from my own interpretation and from the speakers tone (downward moving tone followed by a full stop). Thus, the period after the first word in the above exampe ('Yeah') indicates that it did not appear to me to be connected to 'I think so'. Rather, 'I think so' was a separate thought.

The reader is warned that reading the transcript and listening to the tape are very different experiences. The transcript is an imperfect rendition of the interview. There is much information relating to tone, volume, cadence, gesture, posture that contribute to the verbal exchange, but that are stripped from the transcript. I would expect that this would influence the process of coding and the inferences that emerge from the data analysis process. Conclusions reached through manipulation of the transcript should be verified through the oral record.

Generally, simultaneous utterances were supportive or non-consequential and so were naturally conveyed using the { } convention. In the cases where distinct thoughts were being spoken simultaneously by the interviewer and respondent, this was indicated by [simultaneous:].

Transcripting Conventions

Header: Interview #11
Date interview took place
Physical location of interview
Save code (Wave Pedal)

Interviewee ID Code (This code will persist after the link to personal identifying information is deleted
Interviewer: Wheeler

Notes to interview: Field notes taken before or immediately after the interview relating to researcher observations of setting or respondent that would have a bearing on the data.

Initials: Initials of interviewer or respondent code, followed by a colon

{ } Indicates comments or prompts uttered by the person who is not the primary speaker. Note that this refers to the interviewer when the respondent is speaking, but refers to the respondent when the interviewer is speaking.

( ) Parenthetical comments, non-textual utterances by the primary speaker.

[ ] Indicates explanations or comments that are not part of the flow of the interview, but that relate to that flow. Example: [7 second pause]

? Indicates a distinct upward motion at the end of a sentence, in the way that a question is conventionally ended. In these interviews, use of this symbol is broadened beyond strictly indicating questions.

.. A truncated ellipsis was used to indicate change of direction in a sentence. An ellipsis normally indicates a ‘trailing away of attention’. This was not necessarily the case here. The change would often happen at full spoken cadence. Generally, this symbol was not used to indicate a pause.

……. In early transcripts, a string of periods was used to indicate a pause. Informally, the length of the pause was indicated by the length of the string, at approximately a second per period. In later interviews, I found it less confusing to indicated the length of the pause directly in square brackets. The time value comes from the WavPedal software. Normally, pauses shorter than 3 seconds were not considered significant events and were indicated by an ellipsis or ignored.

'Chuckle' A 'chuckle' is distinguished from a 'laugh' by duration and intensity.

Appendix C

Interview Protocol: George Lesieutre

George Lesieutre, Dept. of Aerospace Engineering Head

17 November 2007

Purpose: to place Sailplane in the larger context of Aerospace Engineering

1. Opening questions:
   a. In what ways have you been directly involved with Sailplane?
   b. Is Sailplane well-known in the department?
   c. Is your overall view of Sailplane positive? Positive within limits? Neutral? Somewhat suspicious? Negative?
   d. Can you recall your first impression of Sailplane?
   e. How would you describe Sailplane to one who had never heard of it?
2. Dimensions of contrast
   a. between Sailplane student and non-sailplane student
   b. Pick an Aero class. Contrast the Sailplane with that other class (which did you pick?)
   c. How is the experience of Sailplane different from that of the larger Aero curriculum
3. Ways in which attributes of Sailplane students embody or symbolize attributes of Aero engineers (designing project courses for the benefit of the Aero Dept: highly technical, fun,)
   a. What adjectives would you use to describe Aero curriculum?
   b. What adjectives to describe Sailplane?
   c. What adjectives would you use to describe typical Aero students near the end of his/her study?
   d. How would you describe the place of Sailplane in the Aero curriculum?
   e. Is the grading of Sailplane consistent with the overall grading in Aero?
   f. What does Sailplane represent in terms of the strategic plan for Aero (past and emerging)? ABET?
   g. What has been the influence of Sailplane on the larger Aero Dept?
   h. How do other faculty in Aero (not involved) regard Sailplane?
   i. How is Sailplane viewed by the College of Engineering, from your experience?

   j. What is the function of Sailplane in the PSU career of Sailplane students?

4. Sailplane as pedagogy
   a. What are the stages of development that a typical high school student goes through to become an Aero eng? What is the next stage after graduation?
   b. How do students learn in Sailplane?
   c. What do students learn in Sailplane?
   d. What is the role of the social dimension in Sailplane?
   e. How important is the social dimension to the student learning of Aero topics?
   f. What is your take on the 'completion' issue. How important is completion? Why?
5. Status of Sailplane faculty
   a. What role did Pipa play in the Aero faculty?
   b. What role does Maughmer play in the Aero faculty?
   c. What role does Maughmer play in Sailplane?
   d. How would you describe Pipa's relationship to Maughmer?
   e. If you took away Sailplane, how would Maughmer's role in the Aero faculty change?
6. Final sum-up questions
   a. Can you describe Sailplane in a word?

Do you expect the student experience of Sailplane will change?

Appendix D Code Table

Code Name	Definition (objective description)	Example
Free Nodes:		
Code Name	Definition (objective description)	Example
Free Nodes:		
1. Facts/Status	Comments relating to facts about the course or project (past or present) or about the status of the Sailplane Project or of individual work.	There's kind of like 2 projects going at once. The one that was designed a few years ago, that you're building now, that kind of went through that whole process and now it's to the building, that's the lab group. {That's the Easy-build, right?} Yeah, the Easy-build and uh..Falcon..um and then the design group is designing what you'll be working on..hopefully after the things that you're building and the lab groups get finished. (S02, Ref 1)
2. Flags	Marker for passages that seem significant to me as I code.	
3. Quotes	Particularly well-stated sentiments or facts. Quotes are marked without correction.	I learned some things in Sailplane class .. that I didn't understand yet. (S03, Ref 5)
4. Stories	Narratives of individual experience	I've been in a lab group with someone who joined their last semester. {Oh!} That was a disaster. {Oh.} Yes. TW: Disaster because they didn't ask questions? S11: No. She um … she kind of thought she knew everything, like how to do it. And she didn't. {Okay, so she..} So, she would do stuff without asking and then it would totally mess up and we would have to completely redo it. Uh. She also.. I don't know, I .. it wasn't just

		that it was her last semester. It was a personality problem, too. {uh huh} Like she got mad one night and just left for like a month and a half and decided to work by herself. {Oh!} Well you can't really work by yourself in a class that's oriented around groups. So. {uh huh} That was weird. (chuckles) I'm not sure that was just a joined in the last semester problem. It might have been a personality issue. {yeah} (S11, Ref 2)
Tree Nodes:		
5 *Course characteristics*	Codes relating to how the Sailplane class is organized and how it is run on a day-to-day basis	It's required for a freshman and sophomores to spend 3 hours a week {okay} in lab. Um I just spend the 3 hours all in one chunk Tuesday nights. Sometimes um due to conflicts, I will I will only have time for 2 hours, but the next week I can make up 4. Just so that it averages out to 3 hours a week. (S05, Ref1)
5.1 Comparisons	Respondent comparisons of Sailplane to other classes and experiences	you learn things (I don't know) life things in this class{uh huh} because you have to deal with people. You have different setting than you sit in a lecture, you're not dealing with the person next to you. (S16, Ref4)
5.1.1 Advantage Descriptors	Expressions of the advantages of Sailplane vis a vis other classes	GL: [3 sec] adjectives [5 sec] Well, I would say it's broad, for one. {uh huh} [8 sec] I'd like to say it was sort of broad, but unifying. Taking all these different kinds of topics {uh huh} but bringing them together in their relationship uh to an aerospace vehicle.(F17, Ref1)
5.2 Cooperative learning environment	References to the Sailplane lab as a cooperative learning environment	lot of them were my friends and I became better friends with them um and that's one of the reasons a lot of them are group leaders and that's one of the reasons I need to continue this project. Um And finish it with them because it's it's not just their goal. It's our goal now. (P1, Ref 4)
5.3 Operational characteristics	References to the logistics of class operation	S01: Well every semester it changes a little bit. Uh You you you Usually there's a there's a design group and a lab group. (Clear throat) The class is essentially two two..it's kind of a dichotomous class. There is the design part of the class and then there is(S01, Ref1)

5.3.1 Grading and evaluation	How are students evaluated and what is the significance of grades	TW: What role does the course grade play in the project? S06: Um, it it doesn't it doesn't really affect me too much. Um, the course grade is based on your peer evaluations. They're very very most important. And teacher evaluations and um the commitment that you have. (S06, Ref2)
5.3.2 Lab characteristics	Descriptions of laboratory content and processes	Maybe you could walk through a typical lab period. Um well like last night, came in layed out all the leading edge pieces, you know our intent for the night was to try a test section lay-up for the inside of the leading edge. (S08, Ref 2 (part))
5.3.3 Class characteristics	Descriptions of class content and process	Say, we're like uh a couple of semesters we did a uh drag build-up on an aircraft. Just calculating all the drags and everything and uh we'd go over that in a lecture and talk about that. I guess that wouldn't be taught every semester, but some of the generally the basics of a of a sailplane of aerodynamics, and things like that are taught every semester. (S10, Ref2)
5.3.4 Student leadership	How one assumes leadership and the role of student leadership in the project work.	TW: At what point did you know that that you'd made it, that you were a part of the group, that you weren't a clueless freshman any more, that you really were a 'Sailplaner'? S09: I guess probably it was actually kind of spring semester sophomore year, when I got put in a group uh like a design group and .. a couple of the seniors weren't around too often for whatever reason, they had other obligations or whatnot and I was kind of running the group. And I was like, "Okay, well, they're not here, I might as well step up and do my best." Obviously, we didn't produce any our report wasn't very very good, 'cause I didn't know too much. (S09, Ref 1)
5.3.5 How decisions are made	In this model of distributed leadership, how are important technical decisions made? Who is responsible for those decisions?	TW: And how will you make that decision? What what will you bring to bear? S13: It's mostly how things fit. Whatever fits will work. {Uh huh} So .. and that's why we need to know where all the controls are going

		to be in the cockpit. So, we can like 1-2-3 up, "Okay, it's best if flaps are over here," then you can decide whether or not that's going to be a steel cable that's going to be controlling those, or a push/pull rod and stuff like that. (S13, Ref1)
5.3.6 Responsibility	Who assumes responsibility for design decisions? Safety? Quality? On-time delivery?	I think there's responsibility for everybody. But, um obviously the older like the junior and seniors will feel more responsibility 'cause they're now the group leaders. (S10, Ref1)
5.4 Philosophy of teaching	Idiosyncratic courses such as this one reflect the teaching philosophy of the teacher. How well is that philosophy communicated to the students?	Dr. Maughmer said, "Yeah, you should just design stuff. Even if it doesn't get made even. Just keep designing stuff. That's the only way you get good at designing things. Just you keep designing." (S09, Ref1)
5.5 Pipa's role	Pipa gives lectures and serves as a knowledge-authority. How is that role projected to the class and how important is it to project work?	The lectures he seems to give right now are pretty basic, like just general things. I don't think anyone even uses them. I know I haven't really used it. What I have used is when I ask him specific questions outside of class. (S12, Ref9)
5.6 Realistic engineering environment	Students assume that professional skills they learn here will be useful to them in a professional engineering environment. In what ways is Sailplane a realistic engineering environment?	It depends on the environment. Like at Lockheed Martin, like you're friends with your Lockheed Martin engineers and that's in part because you can only talk about things with your Lockheed Martin engineer friends. So, like they go out to drinks together and they have their poker nights and I think how much of a family you are it just that's dependent upon the work environment, not necessarily the people in it. {uh huh} So, like they're if a Sailplane person look at it went to Lockheed Martin, you know, they'd almost fit right in. But if they went to someplace where if you had strictly professional relationships? That could be a big change for them. (S14, Ref2)
5.7 Subject matter (SM)	Codes relating to technical subject matter taught and learned in Sailplane	TW: Is it..is the subject matter of the of the course what attracts what keeps you going? Or is it the {oh yeah. It's uh..}dynamics of the interaction?
5.7.1 How SM is	In what ways is technical	S02: It's both, but uh yeah a good portion of it is subject matter. It's

learned	knowledge learned?	not all subject matter, I'd say. At least half of it is subject matter. Un {uh huh} just because I'm really interested in Aerospace. But uh..y'know ever if I was just sort of interested in it, um…it's still fun going to lab anyways, even if you're .. even if for whatever reason, you don't want to do much in a certain lab period or something, y'know you..you might learn a lot about other things just be from talking to other people.. cause they're all all smart kids in Aerospace that know a lot of things about engineering and … um… {uh huh}.Yeah, you just you learn something no matter what. Even if it's (in audible)it's still a fun time. (S02, Ref2)
5.7.2 The nature of the challenge	To build a sailplane in an undergraduate laboratory is a unique challenge. How is the challenge perceived by students?	The point of the class isn't to make you know the best glider that ever there was. It's to understand sailplanes and design and aerodynamics and get a broad knowledge of how everything works and sticks together (S08, Ref2)
5.7.3 What is NOT learned	Linked to next code, what is NOT learned in Sailplane?	GL: Well, I don't really think they are there to build a sailplane. So, I don't agree with the premise. {uh huh} Um … (F17, Ref1)
5.7.4 What is learned in Sailplane	Linked to previous code, what IS learned in this project-based course?	TW: Um..so..Do you think what you'll get out of it is how to build a plane? Or do you think what you'll get out of it is experience with composites? S01: I think yeah those two things plus dealing with people and observing the interactions between people. I mean there's some people that they're they might know a lot about building airplanes, but they really can't talk to people (S01, Ref1)
5.8 Vertical integration	How is vertical integration perceived?	What I love most about Sailplane is that I have friends that are not just sophomores. I actually know juniors, I know seniors, I know graduate students (S04, Ref1)
5.9 "What I like"	What features of Sailplane make it a learning environment that the student values? It is assumed that the features are expressed in order	I really like the hands-on. Just getting out of .. you know you sit in chair-desks all day and different rooms around campus 'cause basically it's all textbook academia and nice to take completely dirty go play in the machine shop. Learn how to weld. I mean I can't think

	of improtance	of any other reason that you know I'd ever do that, but it was a lot of fun and just … playing with all the stuff that you read about in class and like, "Oh! They weren't lying! It really you know it really does do that! (S08, Ref1)
5.10 "What I would change"	What features of Sailplane are frustrating?	I honestly don't believe that our sailplane students will ever be allowed by the University to build and test-fly a an aircraft {Mm} because of liability. {uh huh} Um. I I I think that is a real issue with with the course. {uh huh}And so, it may never get to that point, whereas you know in Germany, they've been doing that for 30 years. (S15, Ref1)