SECTION A

Developing Creative Problem Solvers Using Inquiry–based Instructional Strategies in an Aviation Curriculum

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ABSTRACT

The aviation industry has a need for innovators and problem solvers. An educator's role is to develop students with the proper knowledge, skills, and abilities to meet those needs. However, the students must be intrinsically motivated toward these pursuits in order to be effective, and educators should not introduce factors that discourage creativity and inquisitiveness. This theory–oriented paper identifies the specific skills that students should master and offers a model of instruction that encourages creativity through research, along with recommendations for improvements to the curriculum. Finally, the author provides a select bibliography of strategies for implementing inquiry, creativity, and research activities.

Filling the Need for Problem Solvers

As the aviation industry continues evolving into the 21st century, businesses need employees that can evolve along with them. A survey by the American Management Association (2010) showed that businesses need employees who are not just technically competent, but who can also "think critically, solve problems, innovate, collaborate, and communicate more effectively—and at every level within the organization" (p. 2). Wagner (2012) also builds a case for developing innovative problem solvers when he conducted case studies of different businesses, organizations, and a variety of pre– and post–secondary schools. One particular business leader told Wagner that, "There isn't anyone who doesn't need to be a creative problem solver" (p. 9). The aviation industry recognizes the need for problem solvers as well as Air Washington (2012), a collaboration of aviation manufacturers, government, and community and technical colleges in the State of Washington, listed problem solving as one of the essential skills than new aviation workers must learn before beginning their careers.

The focus on problem–solving abilities does not diminish the need for knowledgeable workers. Knowledge is important, but what people do with that knowledge is becoming more important. The ease of access to information makes learning instant and easy. Anyone can use an internet–connected smart phone or tablet to gain knowledge on demand and use that new knowledge in a manner that fits their current need. This transformation is not unlike the transformation that occurred when Martin Luther translated the Bible into the common tongue. Luther made the teachings in the Bible available to everyone, and the unfiltered availability of that knowledge was an essential moment in the Protestant Reformation (Hamilton, 2007). The world changed during that period not just because knowledge was readily available, but also because people acted in transformative ways by using that knowledge. In today's world, the internet and smart phones are filling the same role as the printing press and binderies did in the 16th century, and that ease of access to information is transforming the way students learn and how they will benefit in the future (Collins, 2006). Wagner (2012) stresses the importance of this shift, stating that "knowing how to apply [knowledge] in new situations or to new problems...matters most" (p. 52). Ramsey (2009) explains the combination of knowledge and behavior more succinctly, stating that success "is 80% behavior and only 20% head knowledge" (2009, p. ix).

This transformation is also changing the roles of teachers and students. If Embry–Riddle desires to develop their students' inquisitive nature and interest in research through the Quality Enhancement Program, *Ignite*, then the university must focus their efforts on developing student behaviors while simultaneously broadening their knowledge. However, efforts to produce these kinds of students will not benefit the industry if the students see the research activities as nothing more than another requirement needed for graduation. If Embry–Riddle wants students to develop a lifelong passion for inquiry and research (instead of periodic efforts that end when they receive their diploma), then the university must create an "environment that is conducive [*sic*] to stimulating thinking that is receptive to original ideas, and [develop] personality traits such as willingness to take a risk and having a sense of humor" (Karkockiene, 2005, p. 54). In short, the desire to be inquisitive and to conduct research must come from within and not be driven by temporary and external reasons (Breen & Lindsay, 2009).

The purpose of this paper is to explore different methods of course and curriculum design that improve the Ignite program's effectiveness while also filling the industry's need for innovators and problem solvers. The research will examine research–based learning and comparable learning methodologies, identify their commonalities, and recommend course and curriculum improvements that will help develop students into lifelong problem solvers and innovators.

Research–Based Learning and Complimentary Methodologies

When teachers expose students to research activities and research–based learning (RBL), they may need to help the students understand the real–world benefits of research and to avoid thinking of it as an academic exercise with no real purpose outside of the classroom (Annerstedt, Garza, Huang–DeVoss, Lindh, & Rydmark, 2010). In actuality, the researcher is a tool that schools, businesses, and organizations can use to create innovative ideas that help fill needs or solve problems. Shaban and Abdulwahed (2012) explain the purpose and benefits of RBL in detail:

> The central focus of RBL is on the development of the learners as independent researchers. This approach is designed to promote, amongst the learners, a commitment to making a difference in the world through intellectual inquiry and creative expression leading to useful and innovative solutions for real–life problems. (p. H4A–16)

The definition and purpose of RBL classifies it as one of the active learning methodologies in constructivist learning theory, in the same family as problem–based learning, project–based learning, and inquiry learning. Activities conducted under these methods are student–led and instructor–guided, which gives the students a measure of autonomy. Critical thinking, research, and analysis are also common, along with goal setting and decision-making. If students are working in a group, they require the students to collaborate. Finally, active–learning activities foster a desire for lifelong learning (see Abdullah, 2001; Carder, Willingham, & Bibb, 2001; and Savery, 2006, for descriptions of specific active–learning methodologies). While all of these methodologies are slightly different, they are all active learning methodologies because each of them requires the students to take an active role in their learning instead of receiving information passively (Bonwell & Eison, 1991; Felder & Brent, 2009).

Bloom's revised taxonomy (Figure 1) shows that students must receive information and utilize the lower–order thinking skills (LOTS) of remembering, understanding, and applying before utilizing the higher–order thinking skills (HOTS) of analyzing, evaluating, and creating. Kirschner, Sweller, and Clark (2006) discouraged the practice of using active–learning exercises to teach without first providing a foundation of knowledge using traditional, passive–learning methods. Both LOTS (passive learning) and HOTS (active learning) are necessary in order to develop a student's knowledge and performance fully.

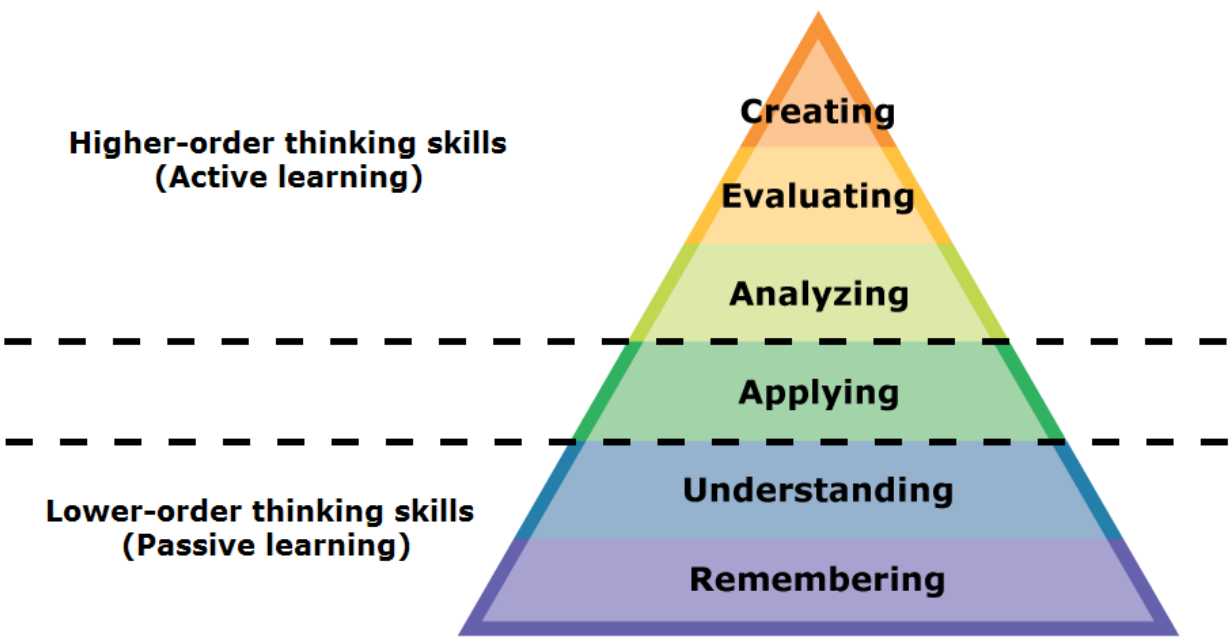

Figure 1. Bloom's revised taxonomy with LOTS and HOTS. The applying skill can be classified as either a LOTS or a HOTS, depending on its usage. If the student applies the knowledge to an existing scenario, then it is a LOTS. However, if the student applies the knowledge in a new and different way, then it demonstrates higher–order thinking. Adapted from "Bloom's Taxonomy" by H. Coffey, 2008. Copyright 2008 by LEARN NC, School of Education, University of North Carolina at Chapel Hill. Adapted with permission.

One notable benefit of active learning is that the method can be used in a variety of courses, even those that are not commonly associated with research. Research activities in mathematics, social sciences, and humanities courses can develop RBL skills even if the subject of the research activity differs from the course material (Brown & Hargis, 2008; Craig & Hale, 2008; Goodman, 2010). By including research activities in a variety of subject areas, students learn to use their entire body of knowledge to help solve problems instead of limiting themselves to the knowledge gained in their core concentration (Sternberg, 2008). This practice should be encouraged. Students should understand that innovative ideas stemming from other fields of study are welcomed in research, and that information and knowledge does not need to be restricted to the current course of study. This thinking is reflected in the Department of Aeronautics undergraduate capstone course, where students are required to demonstrate critical thinking by drawing from multiple sources of information in order to solve problems (Embry–Riddle Aeronautical University [ERAU], 2013).

After examining the common traits of active–learning activities, it becomes easy to see how well they align with the skills that employers look for in today's workers:

1. Critical thinking and problem solving
2. Collaboration across networks and leading by influence
3. Agility and adaptability
4. Initiative and entrepreneurship
5. Accessing and analyzing information
6. Effective oral and written communication
7. Curiosity and imagination (Wagner, 2008, Chapter 1)

Students can learn and develop these key skills by performing RBL and other active–learning activities. It is also worthy to note how Wagner's seven key skills align with the Ignite program's student learning outcomes (see Table 1). By creating research activities that follow

Ignite's student learning outcomes, teachers can help their students develop the proper behaviors and skills that businesses desire today.

Table 1

Alignment Between Ignite Student Learning Outcomes (SLOs) and Wagner's Seven Key Skills

Ignite Student Learning Outcomes	Corresponding Key Skill
SLO–1. Define and/or articulate a research problem	Critical thinking and problem solving, Initiative and entrepreneurship, Curiosity and imagination
SLO–2. Design a course of action to solve a research problem using, as appropriate, multi–disciplinary principles	Agility and adaptability
SLO–3. Apply ethical principles in research	Leading by influence
SLO–4. Conduct research independently and/or collaboratively	Collaboration across networks
SLO–5. Reach decisions or conclusions based on the analysis and synthesis of evidence	Accessing and analyzing information
SLO–6. Communicate research results	Effective oral and written communication

Note. Adapted from "Quality Enhancement Plan, 2012–2017", by Embry–Riddle Aeronautical University, 2012; and "The Global Achievement Gap: Why Even Our Best Schools Don't Teach the New Survival Skills Our Children Need—and What We Can Do About It," by T. Wagner, 2008.

Designing the Curriculum to Grow Problem Solvers

If Embry–Riddle wants to grow problem solvers for the industry, the curriculum must not only provide the tools and knowledge to perform research, but it must also help students realize their own intrinsic desire to be inquisitive and creative (Gitenstein, 2012). The need to foster each student's intrinsic desire for creativity and curiosity needs more emphasis if they are to continue using their research skills after graduation (Tsai, 2012). Knowles (1973) explains an adult's approach to learning as one that derives from an immediate need to solve a specific problem. We can see evidence of this in our own behaviors: If we are presented with a specific problem, whether it is a serious problem or not so serious, and we do not know the answer, we search for the answer online. Alternatively, if we are trying to organize a group to do something, we coordinate efforts through social media. When we run through this process of self–directed learning and group coordination, we demonstrate many of the seven key skills that Wagner (2008) describes. What unlocks those skills is the person's intrinsic motivation to learn or to do.

Wagner (2012) describes three elements necessary to foster intrinsic motivation in students: "play, passion, and purpose" (p. 26). Play allows students to examine ideas, problems, and solutions without penalty. By engaging in play, students develop passions. They are exposed to a variety of topics and discover areas of study that intrigue them, and think nothing of the amount of analysis and research required to understand them fully. Over time, their passions develop a purpose, and they begin on work that fills a need or provides a solution to a problem that is existential and meaningful. By using the play–passion–purpose model to motivate students, teachers give students the freedom to create, to explore, and to apply the information they have learned in innovative ways.

Yew, Chng, and Schmidt (2011) showed that student learning increased by continually running students through the "cycle of problem analysis, self–directed learning, and a subsequent reporting" (p. 449). The Ignite Integration Model provides a systematic method of running students through this cycle by first assessing each student's abilities and providing remedial instruction when necessary. Once the students begin matriculation, they are assigned small research activities that familiarize the student with Ignite's Student Learning Outcomes and allow them to practice and improve their problem analysis, research, and writing skills. As they repeat the cycle, the research activities grow more complex, eventually culminating with the capstone project that demonstrates mastery of the learning outcomes (ERAU, 2012).

However, the emphasis on play—the freedom to think creatively—is essential to this task. Time for creative thought should be allowed. The goal during this time is to help each student discover their inquisitive selves and allow them to explore ideas freely, even if the activity does not follow the typical RBL method (Fasko, 2000). Helping students develop their research skills is still necessary, but secondary. Barnett (1992) best explains the reasoning behind this:

> It is much more important that the student is given an understanding of a conceptual structure, is able to take up stances within it, to understand something of the fundamental debates taking place within it, to see the difference between sense and nonsense, and to be able to stand back and form critical evaluations of the wider social role of the form of thought. (p. 634)

Introducing Play Into Worldwide Courses

Most of Embry–Riddle's courses are already designed with the proper tools to encourage creativity, inquisitiveness, and research; those tools just need to be used in different ways in order to utilize each student's intrinsic motivation. The courses use three different tools to evaluate student performance: quizzes/tests, class discussions, and writing assignments. The quizzes and tests are good tools to evaluate the LOTS. However, the HOTS activities of the class discussions and the writing assignments are not designed to help students develop the behaviors of an inquisitive researcher. Neither of these activities (as they are currently designed) motivate the students towards creative thinking and research for two reasons: First, the activities measure the student's understanding of the course material but give very little feedback about the student's behavior during the process. Second, the activities can shift the student's motivation from intrinsic to extrinsic if the student feels that he/she must sacrifice creativity in order to earn a high grade.

If Embry–Riddle wants their students to become successful researchers and innovators, then teachers must design research activities that emphasize the process of inquiry instead of just the product (Yew, Chng, & Schmidt, 2011). The current focus on the product instead of the process produces negative effects that become apparent when students take the undergraduate capstone course. The capstone course requires two tasks in the first two weeks. First, the students come up with a topic for their capstone. The instructor does not provide topics. Second, they must address that topic from a problem–solving viewpoint and use critical thinking and analysis skills to help solve their stated problem. For many students, this will be the first time they have been asked to think and perform in this manner because their previous courses did not motivate them to think creatively or inquisitively, nor did they help them develop problem–solving skills. Because of those deficiencies, many students do not continue past the proposal phase of the capstone course, and they drop the course or fail. Brown and Hargis (2008) elaborate:

> The typical term paper is little more than an exercise, and the typical student recognizes it as such. Few students perceive the term paper as an intellectual endeavor that should aim to produce results with inherent and enduring scholarly value. (p. 153)

Embry–Riddle can potentially fix this problem by redesigning the discussions and the paper assignments into an activity that promotes inquisitiveness and creativity along with the application of knowledge. Instead of using the discussions and the paper to evaluate the students' understanding of the course material, teachers can turn them into tools that they use in a creative or problem–solving exercise. At the beginning of the term, the instructor can combine the students into a research–study group (or groups, depending on class size), and then task each group to come up with a creative solution that fills a course–related need or problem. The ideas can come from the instructor, the university, or, ideally, from the students themselves. Each group should work on the same problem the entire term instead of focusing on something different each module. As the term progresses, the students will be required to collaborate through the discussion boards, and near the end of the term, each group produces a report that describes their efforts and the results. This method requires the students to alternate between passive–learning and active–learning modes during the term, and the instructor should allow for these shifts and adjust their teaching style accordingly (Fasko, 2000).

Assessing Student Behavior and Outcomes

When assessing each student's performance of the inquiry activity, it is essential to remember that the instructor should be grading the student's behavior during the inquiry process, and that the student's grade should not simply be a reflection of the final product. Over–emphasizing the importance of the final product can shift the student's motivation in the wrong direction, from intrinsic to extrinsic, and discourage students from taking courses that offer creative challenges, opting instead for the higher grades that come from easier courses (Harter, 1978). Hunaiti, Grimaldi, Goven, Mootanah, & Martin (2010) elaborate:

> If the assessment is carried out not for demonstration purposes but with a learning aim in mind, then it becomes a vital part of the learning process, and as such will come with its own intrinsic motivation, rather than being a task that is carried out for an external motivation or reward or for a mark. This is an important point, because intrinsic motivation in the learning process can enhance the student's autonomy and create students who are more likely to become lifelong learners. (p. 191–192)

If Embry–Riddle wants to foster a culture of inquisitiveness in their classes, teachers must not penalize students if they explore ideas that initially seem silly, outrageous, or absurd. Fred Smith, the founder of FedEx, and the story about his term paper at Yale University, provides one famous example. Smith's professor awarded a grade of C with an accompanying note stating that, "that the idea would never work" (Reichert, 2001, p. 42). Fortunately, Smith did not discard his idea after receiving that feedback, but no one knows how many other creative ideas were abandoned because of similar feedback from instructors.

This is not to say that Embry–Riddle should eliminate all standards of performance. However, the university should set performance standards and evaluate students in a way that does not shift student motivation from intrinsic to extrinsic. To do this, teachers must change what they grade and how they grade it. Barge (2010) explains the types of assessments instructors should use in problem or project–based learning activities:

> Forms of both formative (status seminars, peer evaluation, supervisor feedback, etc.) and summative assessment (portfolio assessment, etc.) may be implemented. The greater portion of assessment activity is dedicated to formative assessments, which are designed to develop students' abilities to provide feedback to others and assess their own progress. (p. 18)

One way instructional designers can evaluate the active–learning process is by developing a rubric that evaluates the student's performance of Wagner's (2008) seven key skills: critical thinking and problem solving, collaboration across networks and leading by influence, agility and adaptability, initiative and entrepreneurship, accessing and analyzing information, effective oral and written communication, and curiosity and imagination. This rubric should evaluate each student, even in collaborative projects (Barge, 2010), and use pass/fail scoring instead of calculated numerical scores. If teachers ask their students to be creative and then numerically score the results, then the students may sacrifice inquisitiveness in order to earn a high score. Finally, teachers should remember that the pass/fail grade should not be the only feedback the student receives. The students should get ample feedback from the instructor and their peers during the inquiry process. The goal is to help the students develop the proper behaviors and to encourage creativity without shifting their motivation in the wrong direction.

Sustaining Motivation Though Graduation and Beyond

As each student's inquisitive nature matures through play, the student will eventually discover passions for specific areas of study. These passions will then lead them toward a sense of purpose in their research (Wagner, 2012). The Ignite Integration Model promotes this transition from play to passion and purpose by providing a comprehensive, co–curricular support system that provides information on research opportunities and helps students hone their research and writing skills (ERAU, 2012). One key component is collaborative research, where students and research faculty collaborate on research projects. Dean and Kaiser (2010) offer a model for collaborative research that places the faculty member in the role of the principal investigator in the research effort, while the students fill roles as research apprentices for the principal investigator. This puts the student in direct contact with the "community of practice," (p. 43) a group of faculty principal investigators that regularly apply their research skills. The community of practice can be expanded if the university also engages with private industry to act as a research and development laboratory for developing new technologies. Philbin (2008) describes this expanded method as, "a tool by collaboration practitioners from both academia and industry in order to help facilitate new research collaborations, enhance the transfer of the resulting technology and improve the level of innovation and value creation arising from the technology" (p. 497–498).

By including students in the interaction between research faculty and industry partners, the students can see how their research efforts have a direct impact, thus fueling their passion and focusing their purpose. This kind of collaboration also helps the students learn the research process as they observe the direct application of research methods by the faculty principal investigators. However, it is important to note that faculty principal investigators can have a significant positive or negative effect on the student's motivation. Hu, Kuh, and Gayles (2007) explain the significance of the student–faculty relationship in collaborative research:

> In terms of doing research with a faculty member, the impact of the experience surely must depend on the quality of the relationship between student and faculty member, the length and nature of the research project, the role of the student, and the nature and frequency of feedback the student receives during the endeavor. (Discussion section, para. 5)

As students transition from curricular to co–curricular research, the university may enforce more rigorous standards for performance and grading, but it must conduct these activities in a manner that sustains each student's intrinsic motivation. Otherwise, the experience may deter the student from conducting research after graduation. For example, as each student discovers their passion, they may want to examine the same subject from a different point of view. If this happens, Embry–Riddle must not be overly zealous in their enforcement of the self–plagiarism rules. Otherwise, the desire to stay out of trouble becomes an overriding extrinsic motivator. The university should continue to prohibit students from reusing papers in different courses, but should not discourage students from building a body of research about a particular subject.

Finally, it is important to note that the university may not have enough co–curricular opportunities to accommodate all students enrolled in Worldwide. If applying for co–curricular activities becomes a competitive process, the university should distinguish between students who are intelligent and students who are creative, and favor the latter. Research by Gomez (2007) found a relationship between intelligence and creativity, but not necessarily a correlation, stating that,

> Perhaps the most prevailing view today is that beyond a minimum level of intelligence necessary for mastery in a given field, additional intelligence offers no guarantee of a corresponding increase in creativity. The idea that the more intelligent individual is necessarily the most creative person is fallacious. (p. 32)

One criterion that the university can use to make the distinction is the student's SAT verbal score, where Noftle and Robins (2007) found that "being a verbally intelligent individual has more to do with being creative, imaginative, and inquisitive than it does with being hard working, organized, and industrious" (p. 127).

Conclusion

Embry–Riddle has the capability to produce graduates who can help solve the problems the aviation industry will face in the coming years. Their graduates should be educationally well rounded, technically competent, and naturally inquisitive. They should also have the knowledge, skills, and ability to conduct research that will benefit the aviation industry. However, the motivation to do so must come from within. By introducing creative–learning activities in undergraduate courses, giving students the creative license to explore ideas, and then focusing the scope of those activities over time, their graduates will gain a reputation of being critical thinkers and innovative problem solvers. That recognition will also bring credit upon the university, and may create more opportunities for the university to engage in collaborative research, thus creating more opportunities for the students to make a meaningful impact on the industry.

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Appendix

Resources for Instructors and Instructional Designers

There is a vast amount of information promoting inquiry and research in higher education, but information about strategies for implementing these exercises is necessary as well. The following is a list of resources that can help instructors and instructional designers in a variety of disciplines tap into their students' intrinsic motivation and create a culture of inquisitiveness, creativity, and research.

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