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A Comparison of Adult Learning Characteristics between First-year and Senior Capstone Students

Dr. James J. Pembridge, Embry-Riddle Aeronautical Univ., Daytona Beach

A Comparison of Adult Learning Characteristics between First-year and Senior Capstone Students: A Pilot Instrument to Measure Andragogical Constructs

The ability to teach engineers who are capable of working effectively in a field or discipline relies on an education that is situated in a realistic and comparable environment commonly seen in project-based learning (PBL) courses. A common example of these types of learning environments is represented in design courses, both at the first-year and senior levels. These types of courses require students to exhibit a high level of motivation and advanced cognitive development, representative of an adult learner, in order to successfully meet the requirements of the course.

Studies have acknowledged that in order to develop critical thinkers and capable problem solvers, teachers must understand the needs of today's engineering student and design instruction to meet those needs. The development of students in undergraduate curriculum varies widely as undergraduates have been identified as being in a transitional phase of life between children and adults. This variation has increased recently as an increasing number of non-traditional students enter academia as a result of delayed college enrollment, second career adults, and military veteran undergraduates.

This study explores student motivation and intellectual development by addressing research questions: How do adult learning (andragogical) characteristics of students in first-year design courses compare to those in senior design? and What is the relationship between andragogical characteristics and design learning? These questions will be answered through a survey of student andragogical characteristics composed of several pre-developed and validated instruments associated with their corresponding theoretical framework. This paper describes the development of the pilot instrument to assess the andragogical characteristics based on four theoretical frameworks inferred from Knowles' assumptions: self-directed learning, expectancy-value theory, emerging adulthood, and epistemological beliefs. The frameworks establish a theoretical basis and offer significant insight for the collection of data to assess the role they play in the development of an adult learner. Analyses included several statistical analyses to explore the underlying factor structure of andragogical constructs, key andragogical constructs associated with design learning, and comparison of first-year and senior students.

Findings have identified five major factors that support the use of the theoretical frameworks to operationalize andragogy, while identifying discrepancies among their sub-constructs. Student differences have been primarily associated with developmental areas associated with emerging adulthood. These differences can greatly impact the way design educators mentor their students and coach them through teaming issues, especially for non-traditional students.

Adult Learners in Undergraduate Education

Arnett [1] has recognized that the classification of adult has changed since the 1970's. He has identified a new life stage named "emerging adulthood" where the individual has more autonomy than a child, but is still in a state exploration and just beginning to display the adult characteristics. Because of this new stage, little is known as to whether undergraduate engineering students exhibit the characteristics that meet Knowles assumptions to be considered adult learners. Knowles [2] himself, stated "I don't see andragogy as an ideology at all, but a set of assumptions about learners that needs to be tested for different learners in different situations". If these assumptions are incorrect for a given population of students, the use of andragogical approaches may be limited in their effectiveness.

At the same time undergraduate education is experiencing a surge of enrollment by non-traditional students (over the age of 25). As a result of a more fluid and volatile global economy, characterized by more frequent job and career changes, there is a present need for continual learning and skill enhancement that require adults to remain employable by learning new skills and adapting to new job roles [3]. Therefore, increasing number of adults have begun engaging in some form of adult education over the past decade leading to approximately 44% of the U.S. postsecondary students comprising of adult learners over the age of 24.

Another large source of nontraditional students includes military undergraduates; undergraduate students who are veterans or military service members on active duty or in the reserves. Over the past few years there has been an increase in the enrollment of military undergraduates as a growing number of undergraduates experienced deployment and re-enrollment transitions, particularly as a result of Operation Noble Eagle, Operation Enduring Freedom, and Operation Iraqi Freedom [4]. As defined by 2009 American Council on Education Report of Military Service Members and Veterans in Higher Education [5], their military experience is an identifiable difference from traditional undergraduate student (students who are under the age of 24, fiscally dependent on their parents, and are not veteran or military service members) and nonmilitary nontraditional undergraduates (students who are typically 24 years and older and/or financially independent from their parents, and are not veterans or military service members). While a large focus is placed on support programs, literature has recognized that once the veteran is in the classroom, additional efforts are required as academics are most often listed as a cause for failure [6-8]. Therefore the current group of student service members and veterans serve as pioneers and invaluable sources of information concerning their own experiences, concerns, and questions in the classroom that can shape the landscape of adult education [9, 10].

DiRamio et al. [11] found that both military undergraduates and other non-traditional students can find it difficult to adjust to academic life after being out of the classroom for an extended period of time. They have difficulty in their relationships with college faculty, perceive younger students being immature which leads faculty to underestimate the abilities of the entire class, and treating all students in the course as child learners [12].

Andragogical Frameworks

Knowles [2] coined the term andragogy, meaning the art and science of helping adults learn, whereas the traditional term of pedagogy is the "art and science of teaching children" [13]. Knowles approaches the concept of andragogy and pedagogy as a theory of practices that lies on a continuum, where pedagogy is at one extreme and andragogy at the other with defining assumptions for each (Table 1). The assumptions were developed from Knowles' recognition that the concept of the learner, life experience, readiness to learn, and orientation to learning of the student are different when comparing a child to an adult [2]. He acknowledges that through the process of maturation a person becomes increasingly self-directed, accumulate an increasing amount of life experiences that provide both content and context for learning, and view education as a process to develop competence in professional areas needed to achieve life goals [14].

Table 1. A comparison of pedagogical and andragogical assumptions based on a continuum [2, 15, 16]

Pedagogy		Andragogy
• Learner is dependent on decision of teacher	—	• Self-directed learner
• Few life experiences	—	• Large amount of life experiences
• Learning needs are dictated by the teacher	—	• Learning needs closely related to social roles
• Subject/content-centered	—	• Problem-centered
• Extrinsically motivated	—	• Intrinsically motivated

Since the development of the modern definition of andragogy there have been several attempts to develop a generalized instrument to measure andragogy. These attempts have been focused on the identification of andragogical practices and andragogical learners. The majority of studies that explore andragogy have typically explored the practices associated with teaching in an andragogical manner and employed a quantitative descriptive design to develop a profile of andragogy in an effort to support the theory of andragogy [17]. Few studies have taken steps to explore how learning is different from the pedagogical approach and the andragogical approach through empirical studies. Moreover one of the major criticisms associated with andragogy questions whether the assumptions are either good practices for all learners or key characteristics of the adult learner [18, 19]. This differentiation furthermore relies on the key conception of the andragogical learner involves the clear contrast of life experience between a child and an adult. However at the collegiate level coupled with assumptions related to emerging adulthood, the definition of the adult learner through age, life experience, and social roles used by other studies [19-21] becomes blurred.

Despite attempts, prior studies have had limited due to an emphasis on practice over theory, fail to produce credible outcome measurements, are limited in scope , and do not follow a systematic strategy [22, 23]. As a result Holton et al. [22] state that there has yet to be an "instrument with sound psychometric qualities that validly measure andragogy's six assumptions. While Merriam [16] acknowledges it may be difficult to develop an overarching theory of adult learning, the use of underlying characteristics and theoretical frameworks associated with andragogy make it possible to utilize pre-existing validated instruments to measure the assumptions. This theoretical

and empirical approach facilitates the need to move beyond the philosophical and practice based rhetoric commonly associated with andragogical studies [22].

There are four main theoretical frameworks that can be inferred in Knowles' assumptions: self-directed learning, expectancy-value theory, emerging adulthood, and epistemological beliefs (Table 2). The frameworks establish a theoretical basis and explore the assumptions of andragogy.

Table 2. Theoretical frameworks supporting the assumptions of adult learners

	Motivation		Human Development	
Andragogical Assumptions	**Self-directed Learning**	**Expectancy-Value**	**Emerging Adulthood**	**Epistemological Beliefs**
Self-directed learner	X	-	-	X
Large amount of life experiences	-	-	X	X
Need to know	X	X	-	-
Problem-centered	-	-	-	X
Intrinsically motivated	X	X	-	-
Readiness to learn	X	X	-	X

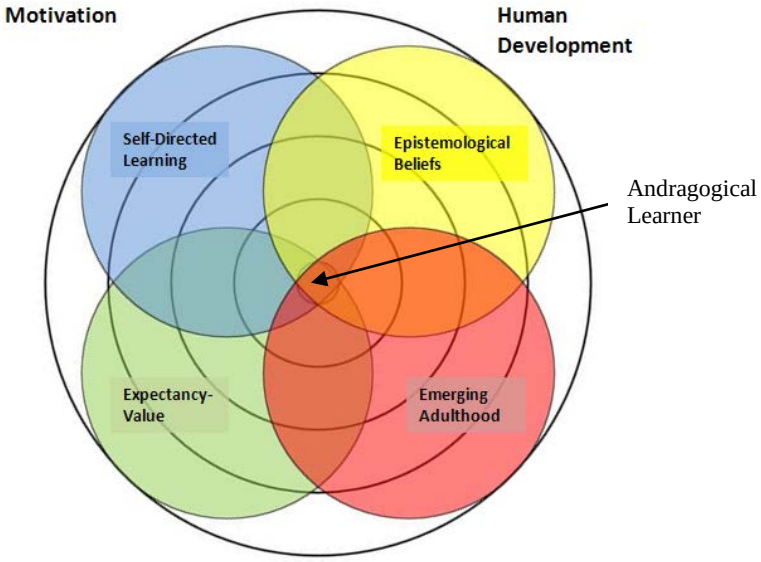

Figure 1. Intersection between theoretical frameworks associated with andragogy.

Self-Directed Learning

Merriam [16] identified self-directed learning as one of the pillars to adult learning. As learners mature they become increasingly more self-directed in their learning [16]. Houle [24] interviewed 22 adult learners and categorized them into three groups: goal oriented, activity oriented, and learning oriented. The learning oriented students were those students that saw "learning as an end in itself"[25]. In his studies, Guglielmino [26] identified that self-direction in learning is

something that all individuals have to some varying degree. He also adds that despite the classroom environment, the student's attitudes, values, and abilities indicate their level of self-directed learning [26]. Based on these factors, a self-directed learner can be described as one who has initiative, independence and persistence in learning [26].

Expectancy-Value Theory

Expectancy-value is comprised of the students' expectancy for success in engineering and the value that they attach to activities related to engineering, like design courses [27, 28]. Eccles et al. [28] identified that value includes *attainment value*, the importance of doing well in an engineering, *intrinsic value*, the enjoyment of engaging in activities like engineering design, and *utility value*, the usefulness of participating in design classes in reaching ones short and long term goals [27, 28]. These components are directly tied to the assumptions for andragogical learners related to their need to know, intrinsic motivation, and readiness to learn respectively.

Emerging Adulthood

Since the 1970's there has been a shift in the demographics of what is perceived as adult as the median age of marriage and first child birth is occurring later, more students are pursuing advanced degrees than any time in the past, and there is little normalization of demographic information between the ages of 18 and 25 [1]. People in this age range have been identified as emerging adults, that are currently in the phase of their life that represents identity exploration; symptomatic of instability, self-focus, a feeling of in-between, and presentation of numerous possibilities [29-31]. People in this point in their life do not recognize with either being an adolescent nor an adult[1]. When pursuing advanced degrees, it has been seen that this group of emerging adults have higher levels of cognitive functioning than adolescents [32]. This cognitive function paired with the independence of developing oneself leads to a recognition that the students are understanding that their learning is important to the definition of their social roles and will lead to a more intrinsic need to identify oneself as an adult and have a competent role in society.

Epistemological Beliefs

Many students enter college in what Kroll [33] refers to as a state of "ignorant certainty," believing that knowledge is certain, beliefs are either right or wrong, the authorities, including their professors, have the answers, and their job is to memorize those answers and repeat them on tests [34]. At best they are only beginning to recognize that not all knowledge is certain and still relying heavily on authorities as sources of truth [34, 35]. As a student becomes an adult learner, they begin to rely less on the teacher as a sole source of knowledge and begin to recognize the complexities of understanding and knowledge for a given domain. Through their life experiences and interactions with teachers and classmates, their beliefs are continuously challenged, the rigidity of their beliefs diminish, intellectual growth increases, and they begin to recognize that not all knowledge is certain [36]. Epistemological beliefs refer to the nature of knowledge and knowing [37]. Through their work, Hofer and Pintrich [37] identified four dimensions of epistemological beliefs: certainty of knowledge, simplicity of knowledge, source of knowing, and justification for

knowing[38]. This model provides an insight into the adult learner's perspective of being problem-centered and having enough life experiences to promote intellectual growth.

Research Questions

As the development of traditional students in undergraduate curriculum varies widely due to being in a transitional phase of life between children and adults as described by emerging adulthood and the increasing population of non-traditional and military undergraduates increases there is a need to explore how student motivation and intellectual development changes through the curriculum. This study explores these issues guided by the theoretical frameworks associated with self-directed learning, expectancy-value, emerging adulthood, and epistemological beliefs answering the following research questions:

> **RQ1.** How do the andragogical characteristics of students in first-year design courses compare to those in senior design?
>
> > **RQ 1a.** How are the differences impacted by age and military status?
>
> **RQ2.** What is the relationship between andragogical characteristics and design learning?

Methods

This study employs an exploratory quantitative research design, that statistically examines responses to a composite survey of andragogical concepts by first-year and senior engineering students enrolled in a design course.

Participants

The sample included students enrolled in the first-year engineering design course and capstone students in the mechanical engineering, civil engineering, and aerospace engineering departments at a small private university in the southern region of the United States. The survey received a 31% response rate for all students enrolled in the courses with 63% representation by the first-year design students with the remainder enrolled in the capstone courses for a total of 325 survey responses. 79% of the total sample respondents were male.

When examining the common descriptors of adulthood (age), the average age of the sample was 20 with a maximum age of 38 and a minimum age of 16. 5% of the sample was over the age of 24 with 6 of those students enrolled in the first-year design course. All of the students above the age of 24 had prior military experience and were classified as military undergraduates. Years of employment can also be an indicator of adult learning orientation as the traditional college student has not had more than 2 years of full-time employment. The sample included 65% who had no prior employment experience, 18% with at least 1 year employment, 17% with 2 or more years and the maximum of 12 years employment.

Data Collection

A student survey was developed as a composite of several pre-developed and validated instruments associated with their corresponding theoretical framework (Table 3). In total the survey has 82 Likert-type items requiring the student to select their agreement with each item's statement. Since the survey is made up of several instruments the Likert-type questions range from selections on a scale of 1-4 and 0-100. Additional items identify survey participants as military undergraduates and will examine common identifications of adults as specified by Knowles [2]. The survey has been validated for content validity by researchers familiar with survey development. It was also validated by a small student pilot to ensure the items were clearly stated. The validation and preliminary data collection indicated the survey takes approximately 20 minutes to complete, thus limiting survey fatigue.

The andragogical measure includes instruments directly measuring the sub-constructs associated with the theories that make up an andragogical perspective identified in Figure 1 and Table 2. The self-directed learning aptitude scale (SLDAS) includes 26 four-point Likert items that range from strongly disagree to strongly agree. The instrument involves questions concerning self-management, motivation, and self-monitoring to learn. Each of these constructs were identified as three distinct, but correlated constructs as a result of factor analysis and correlations [39]. Each of the items associated with the instrument has a composite reliability greater than .75 and a Cronbach alpha greater than .82 [39].

Table 3. Test blueprint for student survey

	Theory	Instrument	Question Type	# of Questions
Andragogical Measures	**Self-directed Learning**	Self-Directed Learning Aptitude Scale (SLDAS) [39]	Likert	26
	Expectancy -Value	Engineering Expectancy and Value Scale (EV) [27]	Likert	9
	Epistemological Beliefs	Epistemological Beliefs Assessment for Engineering (EBAE) [40]	Likert	16
	Emerging Adulthood	Inventory of the Dimensions of Emerging Adulthood (IDEA) [31]	Likert	31
Outcomes	**Self-Efficacy**	Engineering Design Self-Efficacy Instrument [41]	Likert	9
Groupings		Demographic Questions	Varied	14
			Total Items	*105*

The expectancy-value is measured using the Engineering Expectancy and Value Scale (EEVS). The instrument is composed of 9 Likert-type items developed by Eccles and Wiggfield [42] and utilized by Jones et al. [27] in the context of first-year engineering education. The items involve a seven-point scale that has a variety of scales that range from negative to positive evaluations of the items. The items cover the expectancy for success, intrinsic value, attainment value, and utility value of the design course. The evaluations include perceptions of worth, importance, and usefulness. As the study is situated in the context of an engineering design course, the items have been directed towards the students' expectancy and value of the respective design course that they were enrolled in. The instrument was evaluated for content validity and readability by

Jones et al. [27] through a review by experts in engineering education and several first-year students. Additional factorial validation by Eccles and Wigfield [42] indicated strong factorial validity. In their study Jones et al. measured a Cronbach alpha of .82 for success scales, .73 for intrinsic scales, .64 for attainment scales, and .36 for value scales. While .36 was recognized as being a low reliability, Jones et al. note that Eccles and Wigfield saw Cronbach alpha around .62 for their studies.

As the epistemological beliefs that student hold are highly contextual, the epistemological beliefs measure, Epistemological Beliefs Assessment for Engineering (EBAE), has been developed specifically for the context of engineering. The instrument examines the students' nature of knowledge, which includes the certainty and simplicity of engineering knowledge, and the nature of knowing, which includes the source of knowledge in engineering and the justification for knowing engineering. The instrument is made up of 16 items with a 100 point 10 increment Likert scale that ranges from strongly disagree to strongly agree. The items were validated using a confirmatory factor analysis and identified that each of the items were factorial loaded greater than .5 among four factors and accounted for 61% of the variance [40].

The students' status of emerging adulthood is measured using the Inventory of the Dimensions of Emerging Adulthood (IDEA). The instrument includes 31 four-point Likert items that range from strongly disagree to strongly agree. The items require students to answer the questions regarding the identity exploration, experimentation, instability, self-focus, and feeling of in-between over the current five year period that include the past few years and the few years to come. The instrument was supported by exploratory and confirmatory factor analyses for the five-subscales with most items having loadings greater than .45 [31]. Cronbach alpha among the sub-scales ranged between .70 and .85 with test-retest reliability correlations ranging from .64 to .76 with the exception of the feeling in-between scale which was lower than .4 [31].

A self-efficacy measure is also included in the survey as self-efficacy has been directly correlated to academic success in engineering courses. The Engineering Design Self-Efficacy Instrument [41] is composed of 9 items that require students to rate their degree of confidence to perform design tasks on a scale of 0 (cannot do at all) to 100 (highly certain can do). The instrument was criterion validated using respondent engineering experience, in which individuals with varying degrees of engineering experience were successfully differentiated, and content validated, by confirming theoretical relationships between motivation, outcome expectancy, and anxiety [41]. The self-efficacy instrument has a reported Cronbach alpha of .967 [41].

Data Analysis

Data analysis techniques draw on quantitative methods in order to answer the proposed research questions The first research question: *How do the andragogical characteristics of students in first year design courses compare to those in senior design?* will be analyzed using the parametric statistical comparison, ANCOVA, to determine quantitative changes in the survey sub-concept scores between the first-year and capstone design students while controlling for age and military undergraduate status as covariates. Research question two, *What is the relationship between andragogical characteristics and design learning* will be analyzed using a Pearson

correlation to determine a quantitative relationship between student learning and andragogical characteristics.

Findings

Validation and Relationship of Andragogical Frameworks

Analyses also included a principle axis factoring to explore the underlying factor structure of the components of andragogy based on the proposed theoretical frameworks. The principal axis factoring identified 5 major factors: self-directed learning, emerging adulthood, epistemological beliefs, expectancy-value, and a miscellaneous category. A correlation analysis among the 5 factors (Table 4) shows that there is little to no correlation with the exception of expectancy-value that showed a weak correlation to self-directed learning. When analyzed for one factor, all the sub categories explained 24% of the variance. This begins to support the concepts, but identifies discrepancies among sub-measures with low communality.

Table 4. Correlation matrix of identified factors

Factor	Self-Directed Learning	Emerging Adulthood	Epistemological Beliefs	Expectancy-Value	Misc.
Self-Directed Learning	-	-.280	-.037	.446	.110
Self-Directed Learning	-.280	-	.015	-.226	-.255
Epistemological Beliefs	-.037	.015	-	.018	-.163
Expectancy-Value	.446	-.226	.018	-	-.022
Misc.	.110	-.255	-.163	-.022	-

Differences between First-year and Senior Design Students

When examining each of the constructs identified in Table 2, several statistically significant differences are identified between first-year and senior year design students in the areas of self-directed learning, emerging adulthood, and motivation as described by expectancy-value theory (Table 5). In contrast, no significant differences were identified between the two groups with respect to epistemological beliefs (Figure 2). In addition, age and military undergraduate status was identified to be a significant covariate, especially concerning the construct of epistemological beliefs.

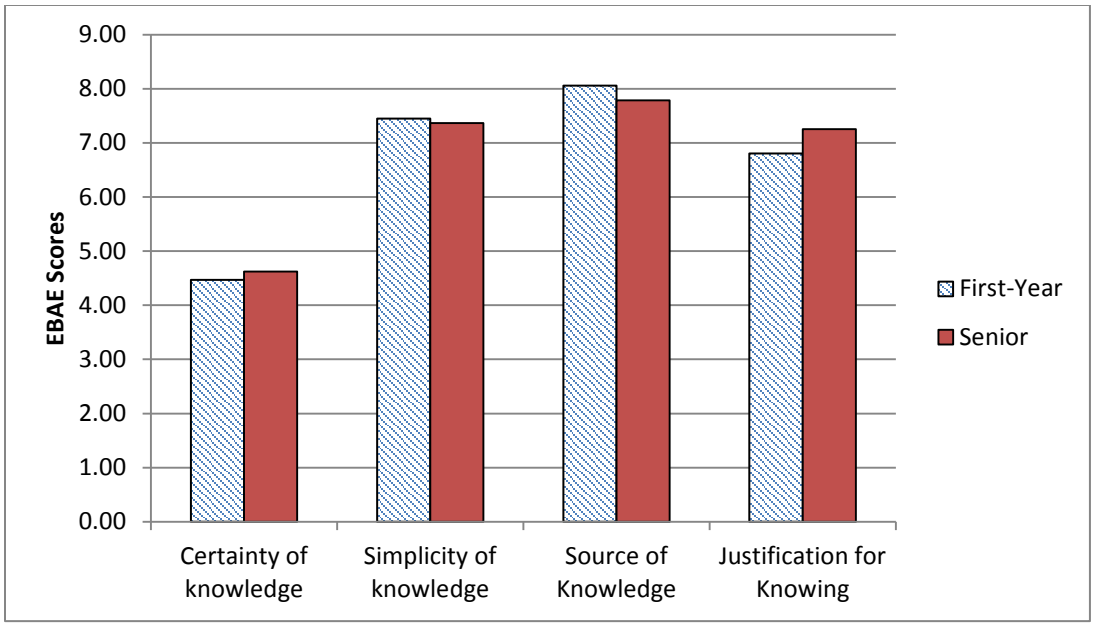

Figure 2. Comparison of first-year and senior student responses to the Epistemological Beliefs Assessment for Engineering (EBAE) concepts scores

The only significantly difference in self-directed learning scores concerned self-management ($p < .01$). As students' progress through undergraduate curriculum they begin to understand their personal approaches to learning and management of time and resources to complete course goals. By proceeding to the capstone design course they have demonstrated an ability to become a better student and should begin to develop skills of life-long learning.

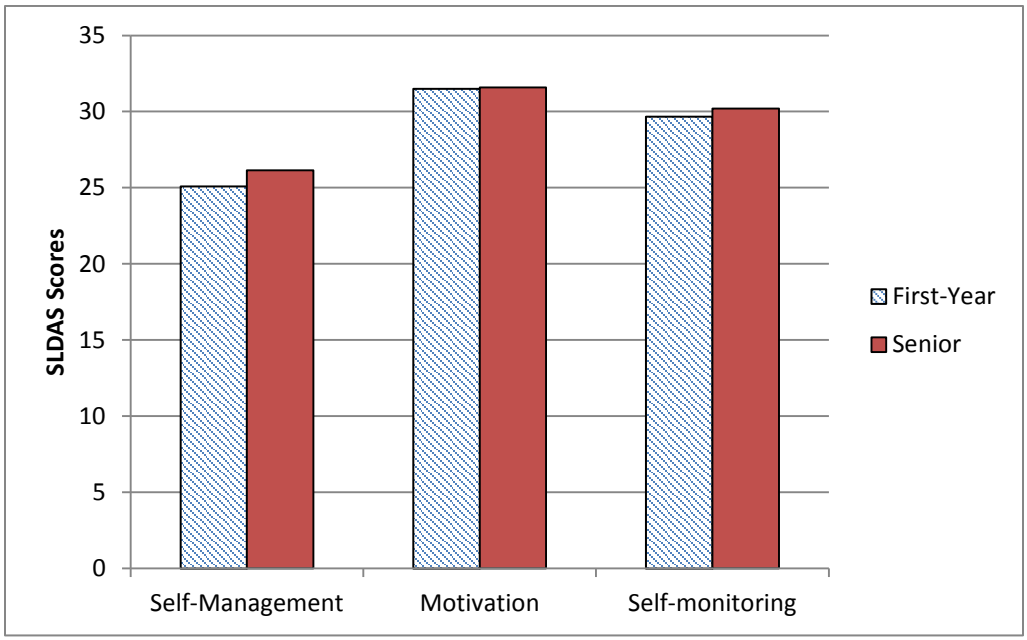

Figure 3. Comparison of first-year and senior student responses to the Self-Directed Learning Dimensions Scale (SLDAS) concept scores

Significantly large differences are observed in undergraduate students with respect to measures associated with emerging adulthood when comparing the two groups. The measures of identity exploration, experimentation and possibilities, self-focused, and feeling "in-between" are all significantly higher ($p < .01$) for first-year design students. Students in the first-year of engineering undergraduate degree often encounter frequent changes in degree focus and life goals and are generally open to new opportunities. In contrast, senior design students experience a significantly higher ($p < .05$) sense of negativity and instability. This can be attributed to identifying and securing a job in the near future and moving onto a new life stage.

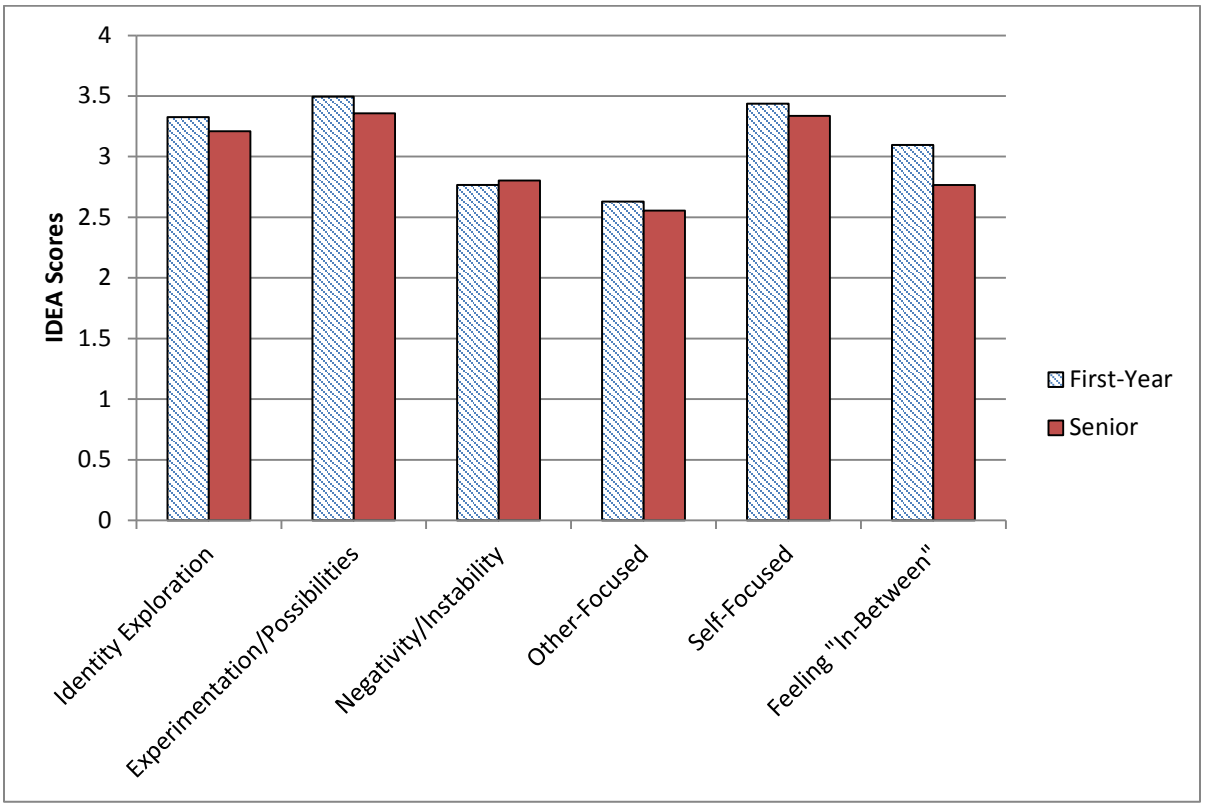

Figure 4. Comparison of first-year and senior student responses to the Inventory of the Dimensions of Emerging Adulthood (IDEA) concepts scores

Additional, significant differences were identified when examining the sub scores of the expectancy-value measure. Findings indicate that the first-year students have higher sense of attainment ($p < .01$) and value ($p < .05$), whereas senior design students have a higher sense of expectancy for success ($p < .01$).

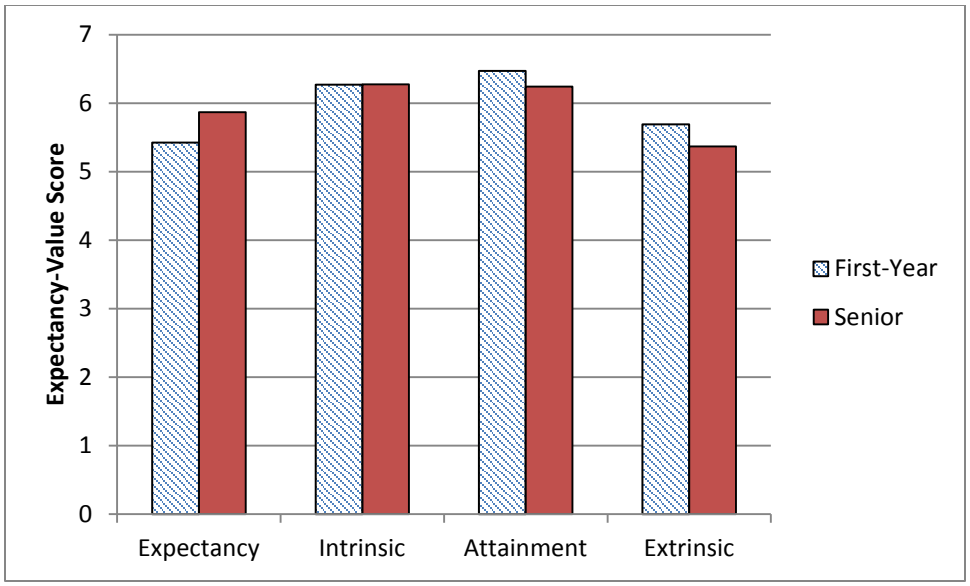

Figure 5. Comparison of first-year and senior student responses to the Expectancy-Value concepts scores

Both military undergraduate status and age were identified as significant covariates for the constructs of emerging adulthood and expectancy-value (Table 5). In comparison to traditional (non-military) undergraduates, undergraduate students with military experience identified less with the emerging adulthood characteristics of identity exploration, experimentation and possibilities, feeling "in-between" while having higher intrinsic motivation than their traditional peers. The military experience has transitioned these students to a more confirmed sense of adulthood, and their decision to pursue an engineering degree, despite academic level is a clear and definitive decision on their part.

While age is highly correlated to military undergraduate status it appears as a statistically significant covariate for the measures of self-directed learning, emerging adulthood, and expectancy-value that is not present for the covariate of being a military undergraduate. Older students identified with more self-monitoring, less negativity, and a higher attainment value than their peers. Once again the lessons learned through age and experience present that as the undergraduate student ages they begin to move out of emerging adulthood and into traditional norms of adulthood, are more capable of monitoring their own learning, and place high motivation on attaining life goals.

Table 5. Statistical findings associated with comparison between first-year and senior year engineering design students

		Mean		
	Cronbach α	**First-year**	**Senior**	**F-statistic**
SLDAS				
Self-Management	0.735	25.10	26.15	4.038**
Motivation	0.752	31.50	31.59	0.166
Self-monitoring	0.752	29.68	30.20	02.365 [a]
IDEA				
Identity Exploration	0.830	3.33	3.21	8.687 ** [b]
Experimentation/Possibilities	0.782	3.50	3.36	5.741** [b]
Negativity/Instability	0.785	2.77	2.80	2.650 * [a, b]
Other-Focused	0.628	2.63	2.55	5.875** [a]
Self-Focused	0.654	3.44	3.34	3.625 **
Feeling "In-Between"	0.768	3.09	2.77	20.502 ** [a, b]
EBAE				
Certainty of knowledge	0.501	4.47	4.62	0.409
Simplicity of knowledge	0.472	7.45	7.36	0.239
Source of knowledge	0.535	8.06	7.78	2.068
Justification for knowing	0.502	6.80	7.26	2.257
Expectancy-Value				
Expectancy	0.807	5.42	5.87	6.736 **
Intrinsic	0.724	6.27	6.27	1.457 [b]
Attainment	0.473	6.47	6.24	5.971 ** [a]
Extrinsic	0.471	5.69	5.37	2.917 *
Self-Efficacy	0.935	70.72	81.66	11.903**
(Listwise N)		(198)	(6)	

* p < .05, ** p < ..01
[a] age, [b] military undergraduate

Relationship between Design Learning and Andragogical Concepts

Self-efficacy has been recognized to have strong positive relationships to student outcomes in a respective course or degree. The self-efficacy of engineering design measure only identified week correlations to the scores related to self-directed learning and expectancy value and no correlation with the emerging adulthood and epistemological beliefs measures (Table 6). The statistical comparison does not present a complete understanding of design learning and more examination is required that can be enhanced by qualitative examinations of student learning with respect to the theoretical frameworks.

Table 6. Statistical correlation between design self-efficacy and andragogical subcomponents

	Self-Efficacy
SLDAS	
Self-Management	0.320
Motivation	0.316
Self-monitoring	0.334
IDEA	
Identity Exploration	0.027
Experimentation/Possibilities	0.063
Negativity/Instability	-0.087
Other-Focused	0.039
Self-Focused	0.065
Feeling "In-Between"	-0.083
EBAE	
Certainty of knowledge	-0.105
Simplicity of knowledge	-0.069
Source of knowledge	-0.026
Justification for knowing	-0.074
Expectancy-Value	
Expectancy	0.353
Intrinsic	0.275
Attainment	0.153
Extrinsic	0.24

Conclusion

The proposed use of a composite theoretical model of andragogy identifies several key elements that aligns with Knowles assumptions. However, additional work is need to further verify their impact with respect to the inclusion of epistemological beliefs and the theories correlation to self-efficacy. Despite these limitations it is clear that there are developmental and motivational differences between first-year and senior design students.

The primary difference between first-year and senior design students is clearly noted in the senior students ability to be stronger at self-directed learning and a stronger sense of adulthood that begins to move them away from the traditional understandings of adolescence and emerging adulthood thus confirming the key transitional period that students encounter in their undergraduate degree. The significance of the covariates for age and military undergraduate status indicate that these are two categories that can alter a student’s perception of the course despite limited connection to course outcomes as described by their sense of self-efficacy.

Implications for Practice

These differences between first-year and senior students offer insight into the ways that design educators can mentor students through problem/project-based (PBL) courses with respect to student accountability, understanding of the nature of knowledge, and ensuring quality teaming experiences necessary for many PBL experiences. The following are recommendations that are supported in other PBL literature, but highlighted here with respect to this study and its findings

First-year students require significant more observation and guidance while proceeding towards the completion of the goal as a result of their lower scores of self-maintenance. Structure is critical for these first-year design students to support their career and psychosocial development throughout their pursuit of engineering an engineering degree. Their higher sense of identity exploration, experimentation, and feeling "in-between" require the support that is need to ensure their commitment and belonging to the engineering discipline. In addition, the first-year students' higher sense of self-focus may present issues related to teaming. Faculty teaching these students may need to provide additional mentoring with respect to teaming and maintain a closer observance of the functionality of the teams.

Non-traditional students exhibit a higher sense of self-monitoring, more focused on the task at hand and have a higher intrinsic motivation and attainment value for the course material. These traits should be capitalized by providing these students with more opportunities for tailored projects and problems. The difference between non-traditional students and their traditional peers with respect to extrinsic and intrinsic motivation support the andragogical assumptions of the student's focus on being problem-centered and focused on attaining their degree for specific life goals. However the lack of difference amongst the groups when examining epistemological beliefs illustrates the need for faculty to advance the students' level of certainty, simplicity, and source of knowledge and justification for knowing to be common across all students, independent of their academic level, age, or prior military experience.

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