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The Foundations of Multi-Disciplinary Behavior: A Factor Analytic Approach

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ABSTRACT

In considering the skill set AECO professionals bring to bear in the realization of the built environment those that address technical issues are usually considered preeminent. However, when issues move beyond those that can be solved by an individual, interpersonal skill may become equally important. Technical and interpersonal skills have a major impact on the nature of the inter-organizational relations that define the AECO industry and these relations are major contributors to the outcome of a project.

The foundation for the technical skills is acquired through a set of prescribed courses during a student's college education. These skills result from a pedagogical approach that results in explicit knowledge. We argue that the interpersonal skills and beliefs are also developed during this period. However, they are predominately a by-product of the pedagogical approach and result in tacit knowledge that prescribes a mode of interaction with other professionals.

In this paper we begin to map the development of this interpersonal skill set. We explore how a student's tacit interpersonal skills change over the course of their college career as a result of the different pedagogical approaches embedded in their courses of study. Understanding how students change as a result of educational experience will help us to develop pedagogical approaches that result in more effective inter-organizational relationships and ultimately superior projects.

KEYWORDS: Inter-organizational Behavior, Machiavellianism, ANOVA

INTRODUCTION

Multi-disciplinary collaboration is recognized as a requirement for superior performance in the realization of projects in the built environment (M. Puddicombe 2009). The work groups that emerge in realizing a project require an interwoven situational awareness resulting in dense social networks that facilitate frequent communication (Sonnenwald 2000). However collaboration between professionals with different disciplinary backgrounds is a complex and dynamic process defined by individuals from different 'thought worlds.' The result is often a lack of synthesis among experts and a reduction in the learning that is necessary for innovation (Dougherty 1992).

This paper proposes that the foundational ability to function within these groups rests with the tacit knowledge that is developed during an actor's professional education. In addition to the technical skills required to be an Architect, Engineer, Constructor or Owner (AECO), the members of the academy implicitly teach a mode of dealing with the others members of the AECO industry. While it is hoped that these processes result in positive process for achieving multi-disciplinary success, evidence suggests that this is not the case. Projects within an academic environment often result in a dynamic that is even more contentious than is encounter within the industry. Anecdotal evidence of this phenomena emerged in an organizational behavior class being taught by one of the authors. The class contained Engineering and

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Management students and was structured to emphasize cross functional learning and group activities. The course was contentious from the start and evidenced significant differences in learning styles and expectations. Reflecting on the conflicts that emerged in the class one of the students commented… “when we started college we all worked together fine. You taught us to behave this way.”

In this paper we hope to shed light on the results of the educational processes that acculturate students to believe and behave in certain ways. We employ the concept of Machiavellianism (Mach) as developed by Christie and Geiss (1970) to begun to understand the tacit learning that results in this contentious dynamic. Their work has laid the foundation for a significant body of research that has examined a wide range of issues related to how individuals function in group situations. While Machiavellianism has been shown to be a multi-dimensional construct it is often associated with the belief “that the ends justify the means”. This perception combined with a social desirability bias has resulted in a negative perception of the term Machiavellian. This study maintains a neutral view towards the construct and employs it as a lens that allows a clearer understanding of the impact of our educational processes.

In the first part of the paper we conduct a literature review that has three parts. The first part briefly reviews the literature of collaboration in general and within the AECO industry. We then examine the emerging literature on interdisciplinary learning in the AECO disciplines. As part of this effort we also briefly examine the positions of the various accrediting bodies as it relates to position and behavior within an AECO context. Lastly, we introduce previous research on Machiavellianism that provides the basis for our study. Based on this foundation we develop a number of hypotheses related to the effects of educational processes on students’ beliefs relative to inter-organizational behavior. In order to test these hypotheses the Mach IV survey was administered to freshman and senior students in Architecture, Engineering, Construction and Management. The results of this survey were analyzed using factor analysis and ANOVA to test the hypotheses. We conclude with a discussion of the results and suggestions for future research.

LITERATURE REVIEW

The Industry

Collaboration between professionals with different disciplinary backgrounds is a complex and dynamic process defined by individuals from different ‘thought worlds.’ While the diversity resulting from these thought worlds is critical in the development of new knowledge it also presents challenges that if not managed effectively can at a minimum result in sub optimization but often result in failure to achieve project goals. Within the AEC industry this condition appears to be far from the exception (Puddicombe, 1997). The result is a lack of synthesis among experts and a reduction in the learning that is necessary for innovation (Dougherty, 1992).

The requirement for multi-disciplinary collaboration rests on the assumption that, “…no single individual (or firm) can acquire the varied and often rapidly expanding information needed for success. Individuals (and firms) must work together to collect, analyze, synthesize and disseminate information throughout the work process.” (Sonnenwald, 2000:461) This assumption is particularly poignant in the construction industry due to its unique form and operation. It is a basic industry, but unlike many manufacturing industries it more accurately reflects a “conglomerate of industries” (Fernandez-Solis 2009). It is defined by variation in the environment, the inputs, and the participants.

The structure of the industry and the complexity of the projects result in interactions that are characterized by misunderstanding and conflict (Emmit 2007). When problems emerge professional's will tend to focus on those issues and solutions that are associated with their profession (Gameson 1992). They will also try to direct the outcome such that it provides the maximum benefit to themselves and their organizations (Loosemore, 1996). This situation describes a condition of contested collaboration "…where team members maintain an outward stance of cooperation but work to further their own interests, at times sabotaging the collaborative effort." (Sonnenwald 2000, 461) This condition would be supported by the diffuse responsibility and authority that is embedded in a project (Love, 2004).

Contested collaboration reflects a Machiavellian approach to the project where each party strives to create and sustain a power base (Liu 2006). As the actors struggle to protect their position, conflicts will increase. The distribution of power allows each party to take ownership of their portion of the project and in theory prevent one party taking more power than the other. This state can hinder project progress by compartmentalizing communications in an attempt to impose their power level. This reduction in the flow of information will negatively impact multiple facets of the project (Patterson 2008).

Professional organizations have begun to respond to this state and its negative affect on the requirement for collaboration. The American Institute of Architects (AIA) has released the A295 family of contracts focused on facilitating 'Integrated Project Delivery.' ConsensusDocs, a consortium of 33 industry associations (including the Associated General Contractors of America (AGC) and Construction Users Roundtable (CURT)), has issued the 300 series of contracts titled the Collaborative Documents (ConsensusDocs 2016). While contracts are an important and highly visible artifact they are just that an artifact. It is the enactment of the contract by individuals that will determine the success of collaboration and the effect on the project.

The Academy

Puddicombe (1997) offered evidence that performance within the built environment required a movement away from planning as an isolated linear process. An iterative process based on learning was required (Figure 1.).

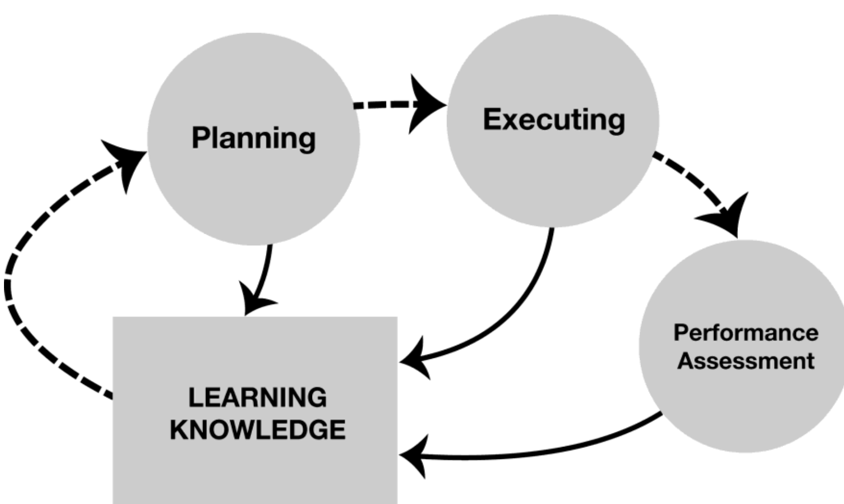

Figure 1. Learning Knowledge Feedback Loop

The reality of an academic environment places constraints on the amount of learning that can result from the actual execution of the plan. However, an interdisciplinary academic environment can readily support learning that results from the planning process. In that context we argue that understanding the dynamics of a collaborative learning environment is critical.

In December 2010, the buildingSmart alliance, a council of the National Institute of Building Sciences, (NIBS 2010)in conjunction with the BIMForum (AGC-AIA 2016)sponsored an academic workshop focused on discussing the core educational principles for technology-based collaboration in the Architecture, Engineering, Constructor, and Owner (AECO) Industry. The participants represented 21 universities and 4 countries. The papers and the panel discussions presented a state of the art view of collaboration in the AEC academy.

The keynote presentation was given by Dan Friedman, Dean of the University of Washington's College of Built Environments and president of the Association of Collegiate Schools of Architecture. His keynote called for a radical reconceptualization of AEC education. The professions must either change or perish. Change is inevitable the question is where the academy will fit in. Fragmented teaching must give way to an integrated approach. This approach must extend beyond the disciplinary skills and requires the inclusion of organizational and social sciences. It is possible to keep the disciplines core values but they must be realized in the context of collaboration.

What follows are brief reviews of the knowledge that was gained and challenges that emerged from collaborative efforts at a number of universities.

Scholars at Virginia Tech (NIBS; Pishdad et al, 2010) believe that social change defined by a collaborative mindset is necessary to overcome the fragmentation that exists in the industry. "Academia is in the best position to drive such transformation through re-visiting the curricula and making required adjustments." (NIBS; Pishdad et al, 2010) In order to begin this change they are in the process of developing an Integrated Real Estate Program that draws on courses from across the university. In addition they have established the Integrated Leadership Studio (NIBS; Taiebat et al, 2010) that combines students from the AEC disciplines as well as students from sophomore through graduate studies. The upper level students lead and mentor the lower level students.

Penn State has begun two experimental courses that integrate AEC students. In order to give the programs the greatest chance of success students were required to submit their academic credentials and were interviewed as part of an application process. Despite these efforts 1/3 of the teams were described as 'highly dysfunctional', and all of the teams faced challenges to collaboration. In post course analysis the instructors found a correlation between the teams collaborative abilities and the quality of the work product. Going forward it was felt that it was important to teach "…techniques which encourage successful collaboration and break down 'discipline silos' as well as the compartmentalization of the design process." (NIBS; Holland et al., 2010)

The University of Washington has developed a problem based collaborative studio that also combines ASEC students (NIBS; Dossick and Pena, 2010). In their approach much of the learning resulted from the friction that took place as the students learned to come to grips with the different disciplines. They describe the task of synthesizing the three disciplines while maintaining a real world context as 'daunting' and identified the technical issues as simple in comparison to those characterized by interdisciplinary collaboration.

The University of Oklahoma (NIBS; McCuen and Fithian, 2010) presented the results gathered over three years on an experimental intersession course that created teams of architecture and construction students. This course offering was unique in that it explicitly included exercises to socialize the students to each other's disciplines. Their experience suggests that explicit exercises in team building, while costly on the front end, pays significant dividends. In addition it is important that the students understand these 'soft' skills as having a basis in science and there importance within their disciplines.

A major outcome of the meeting was the realization that the problem was not embedded in technology but in psychology.

Accreditation

Each of the academic disciplines involved in this study is subject to accreditation by a separate organization; Accreditation Board for Engineering and Technology, Inc. (ABET) for Engineering; the National Architectural Accrediting Board (NAAB) for Architecture; and the American Council for Construction Education (ACCE) for Construction. While there is no specific owner profession, the profession of management and the main accrediting agency, the Association to Advance Collegiate Schools of Business (AACSB), is argued to be an appropriate representation for owners. Given the importance of accreditation in higher education, the standards promulgated by these bodies should have a significant impact on the philosophies, policies and procedures that define the pedagogical experience of the students.

Below are the vision or mission statements of the four accrediting agencies. Not unexpectedly their emphasis is on their distinct professions. What is noteworthy is a lack of any mention of the context in which those professions will be practiced.

- ABET will provide world leadership in assuring quality and in stimulating innovation in applied science, computing, engineering, and technology education.
- NAAB promulgates leadership in, and the establishment of, educational quality assurance standards to enhance the value, relevance, and effectiveness of the architectural profession.
- ACCE is to be a leading global advocate of quality construction education programs and to promote, support, and accredit quality construction education programs.
- AACSB aspire(s) to be the world's leading management education authority and association.

Examination of the specific requirements for accreditation shows evidence that although the multidisciplinary context of practice is recognized; it is emphasized to varying degrees.

In the Program Outcomes for ABET EAC 'an ability to function on multidisciplinary teams' and 'an ability to communicate effectively' are two of 13 outcomes that students must attain. However, when specific programmatic requirements are examined the importance of these outcomes in comparison to technical skills is seen to decrease. In Civil Engineering programs students are required to be able to "…**explain** basic concepts in management, business, public policy, and leadership..." (ABET EAC 2010-2011:10, emphasis added). In Construction Engineering, an **understanding** of legal and professional practice issues related to the construction industry; an **understanding** of construction processes, communications, (ABET EAC 2010-2011:10, emphasis added). This is in contrast to mathematics, sciences, and engineering where the terms **proficiency** and **apply** knowledge that indicate functional capabilities are used. Only in Architectural Engineering is a functional level of expertise required "… an understanding of architectural design and history leading to architectural design that will permit communication, and interaction, with the other design professionals in the execution of building projects." (ABET EAC 2010-2011:7)

The NAAB defines two levels of student accomplishment (NAAB Conditions for Accreditation 2004:11) that are used to guide program development. ***Understanding***—the assimilation and comprehension of information without necessarily being able to see its full implication, and ***Ability*****—**the skill in using specific information to accomplish a task, in correctly selecting the appropriate information, and in applying it to the solution of a specific problem. It also identifies 34 specific areas in which students must demonstrate either understanding or ability. Effective communications skills (1) are identified as a required ability, as is the ability to collaborate (7) in interdisciplinary teams. However, the collaboration is focused solely on the 'design team.' Understanding of human behavior (12) is required, but only in reference to the physical environment. Construction is referenced in terms of understanding cost control (25) and the need for understanding"... the need for architects to provide leadership in the building design and construction process."(32) (NAAB Conditions for Accreditation 2004:11)

The ACCE requires curriculum to lead to '…a leadership role in construction … and the application of evolving knowledge in construction and in the behavioral and quantitative sciences.' (ACCE Document 103:7) The abilities to communicate as well as understand human behavior are identified as 'essential assets'. The construction professional is identified explicitly as a manager and '… must know how to manage the principal resources of the industry, i.e., people and money.' (Business and Management: 12) 'The Constructor must have an understanding of the contribution of the design disciplines' processes. 'The Constructor must be able to communicate with the design professionals, and should be capable of participating during the planning phase of design-build projects.' (Construction Science: 12) Curricula topics should address the constructor's role as a member of a multi-disciplinary team, the assessment of project risk, and the alternate methods that can be used to structure the owner-designer-constructor team. Course work will examine the various roles and responsibilities of project participants throughout a project's life and the creative ways that project teams can be assembled. (Construction: 13)

AACSB while not speaking directly to design and construction, recognizes the importance of understanding group dynamics in Standard 9 which deals with curriculum content. The ability to work effectively with others in a team environment is considered a foundational skill. In addition a basic knowledge area includes understanding group and individual behavior in organizations and society. The multidisciplinary nature of business is also emphasized in that that understanding systems and processes in organizations, including planning and design, and production/operations is also a basic knowledge area. In Standard 10 the importance of students having the opportunities to work together and learn from each other is emphasized (AACSB 2016)

The analysis above suggests that all of the disciplines acknowledge the need for multidisciplinary collaboration. However the degree to which it is emphasized varies dramatically. In both Engineering and Architecture the requirement is subsidiary to the achievement of design knowledge. This is in contrast to the Constructor where the development of collaborative teams is a requirement. It is also foundational to the knowledge and skill set for business.

The differences in emphasis are likely related to the licensing requirement for Architects and Engineers and must be addressed in any curriculum model. Another additional source of conflict could result from area 32 in the NAAB criteria where Architects are encouraged to take a leadership role in construction processes.

Machiavellianism

Often described as the father of political science, Niccolo Machiavelli (1469-1527) was a late-15th, early-16th century, public bureaucrat in the Republic of Florence. In 1513, he wrote his short how-to pamphlet, *The Prince*, as a reflection of his years in 'public service' and as a primer for a newly designated leader of a principality. The book's short, crisp, and ruthless, but emotion-free, advice taught rulers how to acquire and keep power. Machiavelli asks the reader to consider men as they really are, as opposed to how they should be, and deal with them in a realistic manner. His "ends justify the means" theory of political science is frequently derided because of its lack of morality but is evident in practice from before Machiavelli's time to the present. Subsequently, psychologists, sociologists, and organizational behaviorists of the last forty years have taken to evaluating whether individuals employing Machiavelli's tactics and behavior are more or less successful in navigating relationships in today's world.

Seminally, Richard Christie and Florence Geis conducted an extensive review of Machiavellian practices in relation to personality in *Studies in Machiavellianism* (Christie 1970). In this and subsequent studies, the authors developed instruments (surveys) to measure an individual's Machiavellianism. Initially, they asked that respondents answer a statement by choosing one of three descriptors that the researchers considered least to most indicative of a Machiavellian personality. Later, they modified these instruments to present a series of statements, generally drawn from Machiavelli's *The Prince*, which asked respondents to answer, on a Likert Scale from "strongly agree" to "strongly disagree," their reaction to a statement drawn from Machiavelli's advice. This current instrument, the Mach IV scale, consists of a twenty statement survey to which respondents provide answers. (Table 1)

The Machiavellianism construct is assessed using the Mach IV Scale which requires respondents to indicate their level of agreement with each of the 20 statements by using a 7-point scale that ranged from "completely disagree" to "completely agree." Scores can range from 20 to 140, with higher scores indicating greater levels of Machiavellianism. A respondent who strongly disagreed with every Machiavellian view would score a 20 (Low Mach). A person who neither agreed nor disagreed with each Machiavellian view would score 80 (Med Mach). Someone who strongly agreed with every Machiavellian stance would score 140 (High Mach).

The questionnaire focuses on three themes; 1) the endorsement of manipulative tactics and deceit in interpersonal interactions; 2) cynicism about other's weakness and untrustworthiness; and 3) a disregard for conventional morality (Christie 1970) (Fehr 1992). The scale is most detailed about the respondent's views on cynicism and tactics – splitting 18 of its 20 questions evenly between those two categories. A person with a high score on the Mach scale –a high Mach- has confidence in his abilities to manipulate others and believes that people are easily manipulated (Athanasakopoulos 2006).

Researchers have used this instrument to attempt to tease out Machiavellian tendencies from various populations with fairly consistent results. Gabel and Topol (1991) hypothesized that "Managers who adopt manipulative behavior patterns should be more effective (run more profitable operations) than those who are not as adept in developing these behavior patterns". Their results were mixed. A significant relationship in managers' gross margin percentage, but no other statistically significant relationships were observed between Machiavellianism and job performance. Other research seems to demonstrate strong links between Machiavellianism and respondents' judgments that a particular action does not pose an ethical problem (Bass 1999, 188). Among these are: Geiss and Moon (1981); Hegarty and Sims (1978); Hunt and Chonko (1984); and Singhapakdi and Vitell (1990). The research, in general, suggests that highly Machiavellian respondents judge ambiguous actions more leniently and are more likely to form intentions to behave unethically (Bass 1999). Dahling, et al. (2009) reviewed the literature and identified a number of studies that addressed Machiavellianism and organizational criteria such as leadership, economic opportunism, defection, theft, influence tactics, job satisfaction, occupational choice and helping behaviors interpersonal tactics.

Much of the research has viewed Machiavellianism as a unitary construct. However there is increasing evidence that it is multidimensional. Christie and Geiss (1970) implicitly acknowledged this in their recognition that there were themes in the scale. Hunter, et al. (1982) employed structural equation modeling and argued that Machiavellianism has no meaning as a unitary construct. Ahmed and Stewart (1981) identified 5 dimensions that they labeled, Machiavellian tactics, Pollyanna syndrome, Machiavellian tactics negative, Moral ideal and Machiavellian view. Corral and Calvete (2000)examined one, two, three and four factor models for Machiavellianism. Their analysis suggested a four factor model with constructs identified as; 1) Positive Interpersonal Tactics (PIT); 2) Negative Interpersonal Tactics (NIT); 3) Positive view of Human Nature (PHN); and 4) Negative view of Human Nature (NHN). These construct are theoretically consistent with earlier work where Christie (1970) had suggested the distinction between tactics (actions) and views. Others (Ahmed & Steward, 1981) had found that these distinctions could be confounded depending upon the direction of the scale. This could result from a social desirability bias on the part of the respondents. Marlowe and Crowne and Marlowe (1964) describe this as a need for social approval that can be achieved by 'appropriate' behavior. "In a psychometric situation, social desirability would be inferred from a person's attribution of culturally approved statements of oneself and the denial of culturally unacceptable traits." (Arnold 1981, 378)

THE STUDY

Formally, this paper will examine the similarities and differences between Architectural, Engineering, Construction and Business students as it relates to their beliefs relative to behavior in an organizational setting. There are three main hypotheses that emerge from our experience and review of the literature:

> **H1**: (Initial Equivalence) Architectural, Engineering, Construction and Business students enter their respective professional educational paths with no differences in their attitudes as to how to behave in a group situation.
>
> **H2**: (General Learning) During their education, Architectural, Engineering, Construction and Business students develop a set of attitudes relative to group behavior that is different from those that they entered with.
>
> **H3**: (Professional Learning) During their education, Architectural, Engineering, Construction and Business students develop a set of attitudes relative to group behavior that is distinct to their profession

Instrumentation and Data Collection

This study employed the Mach IV scale (Christie 1970). This scale (Table 1) was developed based on the writings of Niccolo Machiavelli and is meant to measure the political personality orientation of leaders in organizations. Political personality reflects the use of formal and informal power to control or manipulate others. The Mach IV test consists of 20 statements to which the subjects respond on a 7 point Likert like scale ranging from Strongly Agree to Strongly Disagree.

This study focused on students as professional cohorts. The scale was distributed to freshman and senior students, at a private college situated in the northeast United States, in each of four disciplines: Architecture, Engineering, Construction Engineering Management, and Management. The sampling results yielded eight distinct sets of responses: freshman Architecture, Engineering, Constructors and Business majors and senior Architecture, Engineering, Constructor and Business majors.

Data was collected via in class completion of the survey instrument. In order to address the social desirability bias, the survey was constructed such that half of the twenty questions were reversed as to their Mach direction and these values were subsequently adjusted (1=7, 2=6 etc.) for data analysis of the overall Mach score. The original values were employed to generate the Mach factors.

1) Never tell anyone the real reason you did something unless it is useful to do so.
2) The best way to handle people is to tell them what they want to hear.
3) One should take action only when sure it is morally right.
4) Most people are basically good and kind.
5) It is safest to assume that all people have a vicious streak and it will come out when they are given a chance.
6) Honesty is the best policy in all cases.
7) There is no excuse for lying to someone else.
8) Generally speaking, people won't work hard unless they're forced to do so.
9) All in all, it is better to be humble and honest than to be important and dishonest.
10) When you ask someone to do something for you, it is best to give the real reasons for wanting it rather than giving reasons which carry more weight.
11) Most people who get ahead in the world lead clean, moral lives.
12) Anyone who completely trusts anyone else is asking for trouble.
13) The biggest difference between most criminals and other people is that the criminals are stupid enough to get caught.
14) Most people are brave.
15) It is wise to flatter important people.
16) It is possible to be good in all respects.
17) P.T. Barnum was wrong when he said that there's a sucker born every minute.
18) It is hard to get ahead without cutting corners here and there.
19) People suffering from incurable diseases should have the choice of being put painlessly to death.
20) Most people forget more easily the death of their parents than the loss of their property.

Table 1: Mach IV Instrument

A total of approximately 170 surveys were collected. Less than 2% of the samples had irreconcilable errors or incomplete information. Data was transcribed by hand from the surveys to Microsoft Excel where it was collated and categorized. Statistical analysis was conducted by importing the Excel data into STATA.

Data Analysis

The analysis consisted of two phases. In the first phase Pomeroy etal (2013) treated Machiavellianism as a unitary construct in this phase it was treated as multi-dimensional. In all cases ANOVA with a Bonferoni adjustment (to account for the multiple comparisons) was employed to determine differences between groups. The Bonferoni adjustment is very conservative in in that errs towards minimizing Type I errors at the expense of potentially introducing Type II errors. It deflates the overall significance level (α) by the number of hypotheses (m) tested. The result is that the significance level is set at α/m. In this and the following analyses we have chosen to stay with this more conservative approach.

Of the twelve individual cohorts, sample sizes varied from $n=13$ to $n=44$, with an average sample size of $n=24.5$. The scores are the average each cohort and indicate that cohorts' agreement or disagreement with Machiavellian precepts. A respondent who strongly disagreed with every Machiavellian view would score a 20 (Low Mach). A person who neither agreed nor disagreed with each Machiavellian view would score 80 (Med Mach). Someone who strongly agreed with every Machiavellian stance would score 140 (High Mach). The results are presented in Table 2.

	Seniors	Freshman	
ARCH	68.62	73	ns
CE	65.86	72.04	ns
CM	68.54	75.28	***0.06***
BUS	78.85	75.64	ns
	0.02	ns	
ALL	71.28	73.07	ns

Table 2: Overall Machiavellianism

Overall, respondents scored in the Med/ Low Mach range with total sample mean of 71.28 for seniors and 73.07 for freshman. There was no statistically significant difference between these two groups (see Table 2). When the two groups were segmented according to discipline and year a statistically significant difference (p <0.02) was observed between seniors but not between freshman. As individual cohorts the Mach index decreased from freshman to senior year for Architectural (ARCH), Engineering (CE) and Construction (CM) students. It increased for Business (BUS) students. However, the only statistically significant difference (75.28 to 68.54; p < 0.06) between freshman and seniors was observed between the Construction students.

The differences between the disciplines was further analyzed (Table 3) and the only statistically significant difference (p <0.03) was observed between Engineering and Business students. The Engineer's Mach index (65.86) was significantly lower than the Business student's index (78.85).

FRESHMAN			
	CE	CM	BUS
ARCH	ns	ns	ns
CM			ns
SENIORS			
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	***0.03***
CM			ns

Table 3: Between disciplines Machiavellianism

The results support Hypothesis 1 (Initial Equivalence) while Hypotheses 2 (General Learning) and 3 (Professional Learning) received weak support. Hypothesis 2 is only supported in relationship to Construction students and Hypothesis 3 is only supported in terms of Engineering and Business students.

As previously discussed there is significant evidence that Machiavellianism is a multidimensional construct. We therefore conducted a confirmatory factor analysis in order to test our hypotheses in a multi-dimensional environment. Based on previous research (Corral and Calvete, 2000) we conducted a four factor confirmatory factor analysis with varimax rotation. As a result of that analysis items 19 and 20 were eliminated due to high uniqueness (0.94 and 0.91) respectively. Eliminating these items is also in keeping with their study in which they eliminated item 19 due to perceived changes in social mores. The results of the analysis (Table 4) closely matched their results. We therefore continued with their naming convention identifying the four factors as Factor1: Positive Interpersonal Tactics (PIT), Factor2: Negative Interpersonal Tactics (NIT), Factor3: Positive view of Human Nature (PHN), and Factor4: Cynical view of Human Nature (CHN).

The factors measure Machiavellian action (tactics) and Machiavellian beliefs (views). They also recognize the potential for a social desirability bias in that respondents may react more negatively to what they perceive as inappropriate beliefs and actions as compared to their positive reaction to what they perceive as appropriate beliefs and actions. A positive score for factors 1 and 3 would be consistent with negative scores for factors 2 and 4. However the intensity of the score may vary. The factor analysis was then employed to compute the four factor scores for each respondent. The factor scores are linear composites for each factor computed as follows; 1) standardize each student's response to a variable with zero mean and unit variance; 2) weight each of these variables by the factor score coefficient (above); and 3) sum the resulting values for each factor. For example in Factor1 items 1, 2, 12, 15, 18 have negative coefficients and are Machiavellian in their orientation. Items 3, 7, 9, 10, 16 have fairly large positive coefficients (>.3) and are not Machiavellian. Respondents who were low Mach's would have theoretically responded that they disagreed with 1, 2, 12, 15, 18 and that they agreed with 3, 7, 9, 10, 16. The result would be a high factor score for Factor1.

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Q1	-0.2251	0.5401	0.0223	0.0805	0.6507
Q2	-0.0898	0.7044	0.0412	-0.0234	0.4935
Q3	0.3545	0.2205	0.0437	-0.2109	0.7793
Q4	0.1349	-0.0200	0.5536	-0.1849	0.6408
Q5	0.0271	0.3809	-0.1162	0.3750	0.7000
Q6	0.6745	-0.1062	0.2781	0.0116	0.4563
Q7	0.6858	-0.0488	-0.0619	-0.0706	0.5184
Q8	0.0242	0.4759	-0.1530	0.1815	0.7166
Q9	0.5261	-0.1999	0.1179	-0.0763	0.6636
Q10	0.3936	-0.0301	0.2160	0.0128	0.7974
Q11	0.1665	0.0742	0.4199	0.1416	0.7704
Q12	-0.1894	0.1373	-0.2391	0.3935	0.7332
Q13	0.0135	0.4393	-0.0629	0.4869	0.5658
Q14	0.1452	-0.0119	0.5570	-0.1552	0.6444
Q15	-0.1236	0.3492	0.1933	0.1933	0.7880
Q16	0.4772	0.0057	0.0786	-0.1842	0.7322
Q17	0.1551	0.1699	0.2726	-0.4637	0.6578
Q18	-0.3080	0.3376	-0.0342	0.3817	0.6443

Table 4: Four Factor Model

These scores were then employed to conduct the cohort analyses in the same manner as had previously been conducted with the MACH index. Tables 5 and 6 consolidate the results of the analysis.

	PIT			NIT			PHN			CHN		
	Seniors	Freshman		Seniors	Freshman		Seniors	Freshman		Seniors	Freshman	
ARCH	0.01	-0.17	ns	-0.03	-0.22	ns	0.02	-0.02	ns	-0.47	-0.13	***0.07***
CE	0.25	-0.04	ns	-0.22	0.03	ns	0.39	-0.07	***0.1***	-0.17	-0.23	ns
CM	0.41	0.18	ns	-0.43	0.19	***0.03***	0.02	-0.29	ns	0.18	0.16	ns
BUS	-0.4	0	***0.09***	0.09	0.18	ns	-0.16	0.11	ns	0.15	0.25	ns
	0.02	ns		ns	ns		***0.08***	ns		***0.02***	***0.04***	
ALL	0.01	0	ns	-0.12	0.07	ns	0.04	-0.02	ns	-0.07	0.04	ns

Table 5: Initial Equivalence and General Learning

PIT			
	FRESHMAN		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	ns
CM			ns
	SENIORS		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	ns
CM			***0.02***

NIT			
	FRESHMAN		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	ns
CM			ns
	SENIORS		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	ns
CM			ns

PHN			
	FRESHMAN		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	ns
CM			ns
	SENIORS		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	***0.06***
CM			ns

CHN			
	FRESHMAN		
	CE	CM	BUS
ARCH	ns	ns	ns
CE		ns	***0.06***
CM			ns
	SENIORS		
	CE	CM	BUS
ARCH	ns	***0.08***	***0.05***
CE		ns	ns
CM			ns

Table 6: Professional Learning

In Table 5 we see support for Hypothesis 1 in that there is no statistically significant difference in the freshman cohorts with the exception of CHN. In Table 6 that difference (p<.06) is seen to be between Civil freshman (-.23) and Business freshman (.25).

Hypothesis 2 is narrowly supported. As can be seen in Table 5 each discipline differs between the freshman and senior cohort, not overall, but on a specific factor.

- The business students moved from a neutral position (0) on positive tactics to a negative view (-.4).
- The Construction Management students moved from a positive position (.19) on negative tactics to a negative view (-.43).
- The Civil Engineering students moved from a negative position (-.07) on positive human nature to a positive view (.39).
- The Architecture moved from a negative position (.19) on cynical human nature to a more negative view (-.47).

Table 7 consolidates these results.

	Seniors	Freshman	
CM	68.54	75.28	***Mach***
ARCH	-0.47	-0.13	***CHN***
CE	0.39	-0.07	***PHN***
CM	-0.43	0.19	***NIT***
BUS	-0.4	0	***PIT***

Table 7: Hypothesis 2 Consolidated Results

Hypothesis 3 is also narrowly supported. As can be seen in Table 6 (at the senior level) each discipline differs from another, not overall, but on a specific factor.

- There is a significant difference on positive tactics between the Construction Management students (.41) and the Business students (-.4).
- There are no differences on negative tactics.
- There is a significant difference on positive human nature between the Civil Engineering students (.39) and the Business students (-.16).
- There is a significant difference on cynical human nature between the Architecture (-.47) and the Business students (.15) and Construction Management students (.18)

Table 8 consolidates these results.

SENIORS			
	CE	CM	BUS
ARCH	ns	CHN	CHN
CE		ns	Mach/PHN
CM			PIT

Table 8: Hypothesis 3 Consolidated Results

DISCUSSION:

The results suggest that students do change from their freshman to senior years in terms of their perceptions as to what is appropriate inter-personal behavior. However the change is more nuisance than hypothesized. While all the disciplines exhibited a neutral to slightly low overall Mach tendency during the freshman year only the Construction students exhibited a significant change. While they were not significantly different from the overall senior cohort they decreased their Mach score from freshman to senior year.

Understanding the pattern of change in the four factors requires an examination of the theoretical underpinnings of the factors. In the original work on Machiavellianism it was suggested that there was a difference in how individuals would respond when the metrics referred to actions as opposed to beliefs. An agreement with a high Mach perspective on human nature did not necessarily translate into agreement with Machiavellian actions.

Architectural students had a significant increase in their rejection of a cynical view of human nature and it was significantly different from the Construction and the Business cohorts. However, there was no such change in the other three factors and their scores were no different than those of the other cohorts. The Engineering students had a significant increase in their support for a positive view of human nature and it was significantly different from the Business cohort. However, there was no such change in the other three factors and their scores were no different than those of the other cohorts. The Construction students had a significant increase in their rejection of Machiavellian tactics but it was not significantly different from the other cohorts. However, there was no such change in the other three factors and their scores were no different than those of the other cohorts. The Business students had a significant increase in their rejection of non-Mach tactics and it was significantly different from the Construction cohort. However there was no such change in the other three factors and their scores were no different than those of the other cohorts.

Considering a positive PIT and a negative NIT and a positive PHN and a negative NHN conceptually equivalent we see some interesting outcomes. Architectural and Engineering students changed relative to beliefs, both exhibiting lower Mach tendencies. The Architects were lower than both the Construction and Business cohorts and the Engineers were lower than the Business cohort. There was no difference between the Architects and Engineers. Construction and Business students changed relative to actions. Construction students exhibited lower Mach tendencies relative to action while Business students exhibited higher Mach tendencies. The Construction cohort was lower than the Business cohort and there was no difference between Architects and Engineers.

If we were to generalize on the results: Students enter the academy without cohort specific differences as to their views of appropriate interpersonal behavior. As they progress through their education Architects and Engineers develop a more positive perspective on human nature than they began with. Constructors develop a stronger set of beliefs that rejects Machiavellian tactics. The business cohort exhibits the opposite tendency and is more supportive of Machiavellian tactics. In their senior year the cohorts do exhibit differences. The Engineering cohort is less Machiavellian and exhibits a more positive view of human nature than the Business cohort. The Architectural cohort exhibits a more positive view of human nature than the Business and the Construction cohort. The Construction cohort is more supportive of non-Machiavellian tactics than the business cohort.

CONCLUSION:

A significant caveat relates to the sample. The current research was conducted at a single period in time. The freshman and the seniors were not the same cohort. Further study employing a longitudinal approach is needed to validate these results.

The results suggest that viewing Machiavellianism as a multi-dimensional construct that focuses on actions and beliefs is appropriate. The differences that were observed on these constructs indicate that further research in this direction could yield a greater understanding of the dynamics that occur in AECO organizations. Of particular interest would be the development of a theory that links Mach beliefs and actions to contested collaboration.

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