Characterization of Project Team Dynamics for Engineering and Management Students Based on Cognitive Style

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Abstract

The problem-solving styles and interpersonal dynamics of project teams are often critical dimensions of the ability of a team to function effectively. In order to study the problem-solving styles of engineering and management students and to track intra-team interactions, the Kirton Adaption-Innovation Inventory (KAI) was used to determine the cognitive styles of the students in Bucknell's Institute for Leadership in Technology and Management (ILTM) during the summer of 2001. The KAI scores were then utilized to interpret and characterize data collected through journaling assignments in which the students recorded their observations about the abilities of project team members to work and communicate with each other. Results show that KAI scores correlate well with both positive and negative aspects of project team experiences.

1.0 Introduction

Each summer at Bucknell University, a select group of 20 undergraduate engineering and management students are invited to participate in Bucknell's Institute for Leadership in Technology and Management (ILTM). The core offerings of the ILTM are an on-campus summer course taken by students after their sophomore year and an off-campus internship completed during the summer after their junior year. The on-campus portion of the ILTM, which is the primary source of material for this paper, engages the students in an extremely intensive six-week program that focuses on issues such as globalization, ethics, communication skills, critical thinking, teamwork, and leadership. The students hear lectures and attend workshops by faculty and corporate leaders, travel to selected industrial and business sites, and work with companies on significant and real-world management and technological projects.

For the project portion of the program, the 20 students are divided into 4 project teams of 5 students each. Each team is assigned a faculty advisor and given a project description developed by a sponsoring company. The projects discussed here were sponsored by General Electric, IBM, Corning, and Brodart Contract Furniture Division and were conducted during the summer of 2001. Although each project team has a faculty advisor, the projects are primarily guided by executives from the sponsoring corporations. The goal of each project is to expose the students to a real and significant corporate initiative that has both technological and managerial dimensions, as well as to let them experience the conflicts and management issues that can arise in an intensive team environment.

Traditionally, the project teams are assembled to maximize heterogeneity in three areas: gender, major, and grade point average (GPA). The heterogeneity of the project teams is sought not only to balance the capabilities and skill sets of the groups, but also to force the students to work with

others who may have very different approaches to problem solving. Previous experience has shown that although the teams are designed to be as similar as possible, some teams inevitably function much better than others, and quite often at least one team suffers significant problems with their "team dynamics."

In order to investigate and better establish the functional heterogeneity (or homogeneity) of the teams, cognitive style theory and the Kirton Adaption-Innovation Inventory (KAI) were introduced into the ILTM on-campus program in the summer of 2001. Kirton's Adaption-Innovation theory is based on the assumption that individual cognitive differences in approaches to problem solving produce distinctive patterns of behavior, and these differences can be identified by means of a relatively simple psychological instrument. Moreover, Kirton's work indicates that significant differences in the approaches of project team members to problem solving (as indicated by differences of 20 points or more in KAI scores) can lead to serious difficulties in the functioning, communication, and collaboration of team members.

The goal of the present study was to investigate whether KAI scores can be used effectively to develop correlations and draw conclusions about project team dynamics for engineering and management students, both in the ILTM program and elsewhere. This was accomplished during the summer of 2001 by determining the KAI scores of the students in the program, as well as the faculty advisors, and then tracking the progress of the project teams through student journal entries and faculty observations.

In addition to a brief summary of Kirton's cognitive style theory, this paper will present specific data collected during the study, including KAI score distributions and sample anonymous excerpts from journal entries. Our results show that KAI scores can be used to help students understand and appreciate the different problem solving strategies of others, as well as to predict potential "trouble spots" within project teams as they carry out their work. These results will form the basis for additional studies of ILTM students and other student teams in the future.

2.0 Overview of ILTM Program and Problem Identification

Program Background

Bucknell's Institute for Leadership in Technology and Management (ILTM) was founded in 1991 with a gift of $1 million by former Bucknell student and current trustee Larry Breakiron as part of the establishment of the Lauren P. Breakiron Technology and Management Fund. The founding faculty, in the summers of 1991 and 1992, established the curricular goals and fundamental structure for "an integrated academic program to address the challenges of technological change and the changing global economy." Fundamental guiding principles that were identified at that time were:

- To integrate engineering and management knowledge in order to provide students with a more holistic view of technologically sophisticated and complex corporate and industry problems;

- To integrate conceptual and theoretical knowledge with practice in the engineering and management professions.

The structure developed for the program provided for a two-summer intensive experience for students majoring either in one of the five engineering departments at Bucknell (Chemical, Civil and Environmental, Computer, Electrical, or Mechanical Engineering) or in Management or Accounting, with the goal of making available to Bucknell students a learning experience that bridges the disciplines of engineering and management. The two summers of the program were constructed around on-campus course and project work for students who have completed their sophomore year and an off-campus internship experience for continuing ILTM students after their junior year. The first offering of the on-campus component of the program was in 1993, and the tenth anniversary class will be enrolled in June of this year.

Entry into the ILTM is by application only and limited to a total of 20 students. Thus, each summer brings together 20 of the very best and most highly motivated rising juniors in engineering and management. The curriculum is developed each year by four core faculty in the Institute and offers a unique interdisciplinary combination of topics taught by core faculty, a number of adjunct faculty, and outside speakers, including four day-long sessions with executives-in-residence. The content of the program is intentionally very ambitious with correspondingly high expectations for the students.

A principal component of the program is field trips to several (usually four) industrial or business sites. These field trips are typically day-long visits (occasionally overnight) and for the 2001 program they were to Corning, G.E. Industrial Systems, NBC, and IBM Microelectronics Division. During the field trips, the students interact with corporate executives, as well as recently hired employees, and tour engineering and production facilities. Each field trip is also coordinated with four interdisciplinary corporate team projects in which the students in the program are required to participate.

The project assignments focus on real-world technological and management issues for the sponsoring companies. Typical projects in recent years have included work with J.P. Morgan to develop and evaluate its on-line business presence, with Penn State Geisinger Health Systems to evaluate a new "Urgent Care" patient service, with G.E. Industrial Systems to evaluate and refine on-line sales strategies for the transmission and distribution segment of its utility market products, and with IBM Microelectronics Division to assess the market potential for Third Generation (3G) wireless technologies. To be effective for both students and sponsoring companies, these projects require significant corporate involvement, including active participation by corporate liaisons. At the conclusion of the project, company representatives attend the project final presentation, are encouraged to aggressively question the students on their work, and receive the students' final report. Over the nine years of the program, other companies that have sponsored ILTM projects include Armstrong World Industries, Carlisle Tire & Rubber Company, Ford Motor Company, G.E. Transportation Systems, Hershey Foods, Johnson & Johnson, PPL Corporation, and Proctor & Gamble.

In the second summer of the ILTM, rising juniors who have completed the first summer's program participate in an off-campus internship that has four overarching goals:

- To expose students to executive management and decision making processes;
- To give students opportunities to experience and participate in corporate approaches to both day-to-day problem solving and strategic planning;
- To require students to be active contributors (not just observers) of typical business practices;
- To prepare students to become leaders of companies conducting business centered in product and informational technologies.

These goals are achieved by placing students in ten-week (minimum) paid internships that require them to work in a position at the confluence of business and technical decision making. As in the on-campus portion of the ILTM, the standards set for the students are intended to be high, with the expectation that they will have the opportunity to experience first-hand the "real-life" demands and responsibilities of the corporate world. Internships typically fall into one of three categories: Project Oriented, Shadow-to-an-Executive, or Executive Assistant. A Project Oriented internship is usually the least preferred model for ILTM students, but it has nonetheless been successful, particularly for those students who have strong analysis and written communication skills. The more desirable internship forms are either for a student to be "partnered" with a mid-level executive, shadowing his or her activities and learning much in the same way as an apprentice, or to serve as an Executive Assistant and act in a paraprofessional role for a senior executive. The interested reader is referred to Gruver and Stamos[1] for additional information on typical ILTM internships.

To receive academic credit for an internship, a student must submit a detailed report of their internship activities (including an analysis of the relationship of the on-campus portion of the ILTM program to the internship), a portfolio of representative samples of their internship work (respecting confidentiality agreements), and a daily journal of internship experiences. The host company is asked to complete a one-page evaluation of the work of the intern, which also becomes part of the material on which the grade of the student is based. A partial list of companies that have sponsored ILTM interns includes ARCO Chemical, Boston Scientific, Chase Manhatten Bank, Corning, G.E. Industrial Systems, G.E. Medical Systems, Goldman, Sachs & Co., IBM, Johnson & Johnson, J.P. Morgan, Lockheed Martin, Merck, Motorola, PricewaterhouseCoopers, Siemens, and UPS.

Although both the on-campus and off-campus portions of the program are exceptionally demanding, the responses of students have been overwhelmingly positive. A small sample of students' comments provided in past years at the end of the on-campus portion of the program include:

- "The ILTM program has been one of the best experiences that I have ever had. … Besides learning about leadership and 'thinking outside the box,' I have taken away the fact that some of the best lessons in life have been taught because you have failed."
- "This program was very unique – unlike anything that I would take during the school year. … The things I learned here are crucial to survival in the real world: working

in a team; being more aware of what's happening in the world; how to give good presentations; and about the dynamics of human resource management."
- "Not only did I learn a lot of information about a wide variety of subjects, but I learned how to solve problems critically and completely."

The impact of the ILTM program on our students while they are at Bucknell is exceptional. We hope that it is at least equally relevant to their future careers, preparing them to become leaders of institutions that can take advantage of the unprecedented technological, information, and environmental changes occurring in the world today, and that also understand the need to act ethically and responsibly to sustain a healthy balance between man and his technologies and the global environment and economy.

Overview of 2001 Program

For the summer of 2001, the 20 students enrolled in the program consisted of 9 Engineering majors (2 Chemical, 1 Civil and Environmental, 1 Computer, 1 Electrical, and 4 Mechanical) and 11 Management and Accounting majors (8 Management and 3 Accounting). These 20 students were selected from a pool of 44 applicants (16 Engineering students and 28 Management and Accounting majors). The final 20 students consisted of 9 females and 11 males, with GPA's that ranged from 3.00 to 3.91 with a mean of 3.51.

The curriculum for the summer of 2001 was typical for the program and consisted of six weeks of classes, field trips, and project work, with nominally 6 hours of class per day (occasionally more). Students were also given numerous reading, homework, and presentation assignments to be completed during the evenings. Occasional time was set aside for project work (typically 3 hours per week), with the sixth week dedicated to project report completion and presentation. A clear indication of the range of activities in which the students were involved is given in Figure 1. This figure displays the schedule of classes and field trips for the second week of the 2001 program. As can be seen, students participated in classes from 9 to 12 and 1 to 4 daily, with occasional evening sessions. Classroom topics included Teamwork and Conflict Resolution, Leadership, Marketing, Emotional Intelligence, Presentation Skills, and Human Resources, as well as a session with retired Goldman Sachs general partner, William Gruver. This week of the program also included a one-day field trip to Corning in Corning, New York.

Project Descriptions

For the project portion of the on-campus component of the 2001 ILTM program, four sponsoring companies were involved: G.E. Industrial Systems in Plainville, Connecticut; Corning in Corning, New York; Brodart Contract Furniture Division (manufacturer of custom library furniture) in McElhatten, Pennsylvania; and IBM Microelectronics Division in East Fishkill, New York. Each project team was assigned to one of the four project sponsors. Each project was also assigned a core faculty advisor, and corporate liaisons were identified at each of the companies. Although the core faculty advisors are available to monitor progress and to ensure that students do not lead themselves down a path that would be disastrous for the project, the projects are primarily guided by mentoring executives from the sponsoring corporations.

WEEK 2

Time	Monday June 18, 2001	Tuesday June 19, 2001	Wednesday June 20, 2001	Thursday June 21, 2001	Friday June 22, 2001
9:00am	Teamwork and Conflict Resolution Mr. Wise T012	(9:30am) Two Cases in Leadership Prof. Gruver T113	**(6:30am Departure!!!)** Field Trip Corning Corning, NY	Marketing Prof. Allen T113	Transportation and Logistics Prof. Willoughby T113
1:00pm	Operations Management Prof. Willoughby T113	(noon) Reflections Profs. Gruver & Stamos LC217	Field Trip Corning Corning, NY	Managing Human Resources Prof. Pagana T113	Working with Emotional Intelligence Prof. Pagana T113
7:00pm		(8:00pm) PBS Program Prof. Stamos, LC301		Presentation Skills Ms. Cronin, T203	

Figure 1: Week 2 of ILTM Program Syllabus (2001)

For the summer of 2001, the problem statements for the four projects are summarized below:

- **G.E. Industrial Systems (GEIS):** Provide a recommendation of both short-term and long-term strategies to improve the services provided by GEIS systems to their customers by examining GEIS's current business model of providing products to utilities customers, benchmarking major competitors' business models, researching the needs of GEIS customers, and investigating the current trends and forecasts for several types of e-business.

- **Corning:** Determine the level of investment in marketing and manufacturing resources Corning should make in their Selective Catalytic Reduction (SCR) emission control technology to be successful in the global air pollution market.

- **Brodart Contract Furniture Division:** Examine and analyze the manufacturing processes at Brodart's custom library furniture production facilities in order to make recommendations for their on-going re-engineering efforts.

- **IBM Microelectronics Division:** Assess the market potential of Third Generation (3G) Technology by understanding how consumers and businesses will interact with these devices in different situations. The end goal is to provide IBM with a marketing strategy for a future 3G device.

Each of these projects was in an area in which the students had very limited expertise (and in many cases, no experience at all) and required them to assemble and assimilate large amounts of new information, understand the true goals of the problem statement, and think critically about the proper way to address them.

Team Descriptions

Traditionally, the project teams are assembled to maximize heterogeneity in three areas: gender, major, and grade point average (GPA). This same approach was followed in the summer of 2001. Although KAI scores for the students were available when the teams were assembled, we decided not to consider them in the development of the project teams this year. The goal for this

introductory year of KAI analysis in the program was to develop a baseline for future comparison based on the approach to project team formation used in the past. Thus, for the summer of 2001, each of the 4 project teams consisted of:

- 2 females and 3 males (with one group of 3 females and 2 males);
- 3 management/accounting majors and 2 engineering majors (with one group of 3 engineering majors and 2 management/accounting majors);
- 1 student with a GPA less than 3.3, 2 students with GPA's between 3.3 and 3.7, and 2 students with GPA's greater than 3.7.

Furthermore, the breakdown of the individual disciplines within the Engineering and Management/Accounting majors was such that each team contained 1 Mechanical Engineer, 2 Management majors, and 1 Accounting major (except for one team that did not have an Accounting major). For reference, Team 1 was assigned to the G.E. Industrial Systems project, Team 2 to Corning, Team 3 to Brodart, and Team 4 to IBM.

Although the traditional ILTM approach to project team development balances gender, disciplinary background, skill sets, and intellectual capacity, it does not balance the teams' advantages and disadvantages as they relate to cognitive style. Thus, as has been observed in past years, certain teams function much more cohesively than others, and some teams are much better suited to their project, based on whether the project focuses on the development of a wide range of new ideas or the detailed refinement of existing ideas. Moreover, the intensity of the ILTM program and the strong emphasis on teamwork causes these issues, their associated conflicts, and personality and communication differences to occasionally boil over into crises in the six short weeks of the program. Thus, the application of cognitive style theory was introduced to explore the characterization of these and other issues associated with team dynamics.

3.0 Cognitive Theory Background

This study relies on the cognitive style theory of Dr. Michael J. Kirton, an eminent British organizational psychologist. This theory is well established and has been highly validated in practice for over 25 years, with hundreds of international journal articles and graduate theses devoted to its study and application. Only a brief summary of this theory will be presented here, but interested readers may find further details in Kirton's major works[3,4,6].

Kirton's Adaption-Innovation Theory is based on the assumption that all people solve problems and are creative, since both are the results of the same brain function. The theory distinguishes carefully between *level* and *style* of problem solving and creativity, or more simply, between cognitive level and cognitive style. *Cognitive level* refers to an individual's inherent potential capacity (such as intelligence) or learned capacity (such as managerial competence). *Cognitive style*, on the other hand, is defined as the "strategic, stable, characteristic, preferred manner in which people respond to and seek to bring about change" (including the solution of problems)[6], and it is these preferences with which A-I theory is concerned. Cognitive level must be assessed by other means.

Cognitive style differences, as measured by the Kirton Adaption-Innovation Inventory (or KAI), lie on a continuum and range from strong adaption to strong innovation (see Figure 2). For large general populations, the distribution of scores forms a normal curve. Smaller groups can be predictably different from general populations, depending on their problem-solving orientation, and may exhibit skewed distributions about different means.

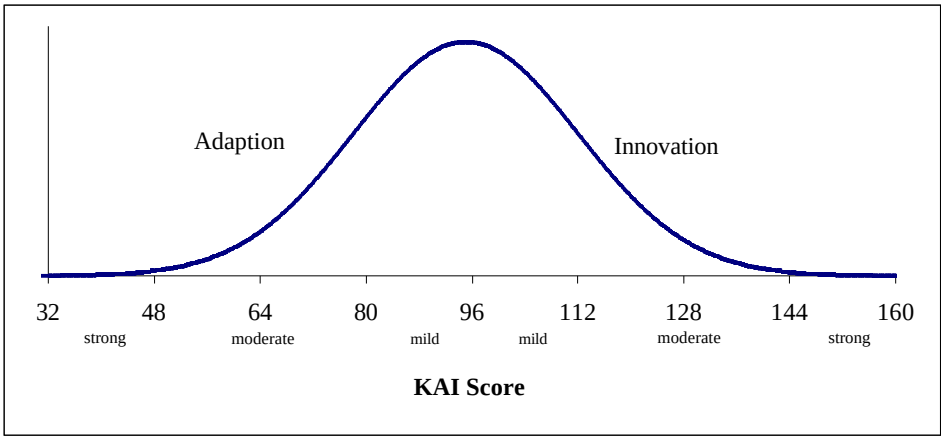

Figure 2: The Adaption-Innovation Continuum

One key distinction to the differences between adaptive and innovative individuals may be described as follows: Individuals who are more adaptive prefer to operate with more structure, and with more of this structure consensually agreed, than do more innovative individuals. More innovative individuals prefer solving problems with less structure, and they are less concerned with consensus concerning the structure's design or even existence[3,4]. Please note the use of the terms "more adaptive" and "more innovative" in this paper. These terms are more precise for describing such a continuous range of styles, and they are preferable to the terms "adaptors" and "innovators", which incorrectly imply two separate "boxed" types.

In general, more adaptive individuals approach problems from within the given frame of reference (or paradigm) and strive to produce solutions that are "better" rather than "different". The value of these individuals is obvious, since they tend to be the system experts and are dedicated to its maintenance and efficiency. In other words, they are especially good at fine-tuning the current rules and procedures in order to make them operate as effectively as possible. The more innovative, on the other hand, tend to detach a given problem from its customary frame of reference and search for solutions that are typically seen as "different", although they may or may not be "better". One way of summarizing this basic difference is to say that more adaptive individuals prefer to solve problems *using* the rules, while more innovative individuals tend to solve (the same) problems *despite* the rules[5].

These differences in cognitive style produce distinctive patterns of behavior, which are particularly important when groups of individuals come together to solve problems collaboratively. Problem solving is commonly considered to include the following stages: problem definition, the collection of data, idea generation, evaluation of solutions, and final solution implementation[8]. More adaptive problem solvers generally accept problems as they

have been defined, along with any agreed-upon constraints. In collecting data, they tend to be exhaustive and favor information and perspectives that are closely related to the original problem structure. When generating ideas, more adaptive individuals prefer to generate a few novel and creative solutions that are relevant, readily acceptable, and aimed at improvements on the current paradigm. These solutions are often relatively easier to implement than solutions generated by a more innovative person. When evaluating and implementing solutions, the more adaptive problem solver looks for a quick resolution to the problem which will limit disruption and immediately increase efficiency[2,4,5].

More innovative problem solvers, on the other hand, tend to reject the original, generally accepted definition of a problem and redefine it. This new view of the problem may be difficult to communicate to others, but it may also bring new clarity. In collecting data, the more innovative tend to look outside the original problem structure for different perspectives, which they bring into the solution process. When generating ideas, more innovative individuals generally produce numerous novel and creative ideas, some of which are not acceptable to others or may not appear relevant to the problem. When evaluating and implementing solutions, the more innovative problem solver is less concerned with immediate efficiency and potential disruption, and tends to look ahead to potential long-term gains[2,4,5].

A few additional comments concerning the problem definition stage are appropriate here. For a more adaptive individual, the chief aim of this stage is to define the problem as explicitly as possible in a way that is acceptable to authority and hopefully to other members of the team. If a problem definition is supplied at the outset, a more adaptive person will accept this definition as fixed, clarify any questions he or she has about details, and endeavor to move forward to a quick solution. If any part of the problem is not well defined, the more adaptive person tends to be frustrated by the ambiguity and may have difficulty moving beyond this stage. For a more innovative individual, the problem definition stage can be very enjoyable if he or she is given some freedom to explore different problem formulations. Innovators delight in defining and redefining problems using new perspectives, even when a problem statement is supplied. This can lead to difficulties, however, if they have not learned to discipline themselves and converge on a definition in a reasonable time. Further discussion of these and other implications may be found in Kirton[4,5] and Jablokow[2].

4.0 Application of KAI to ILTM

The KAI Inventory

The Kirton Adaption-Innovation Inventory[3] (KAI) was introduced in 1976 and measures preferred thinking, or cognitive, style. Respondents answer 33 questions that focus on how easy or difficult it is for a person to present himself consistently, over a long period of time, in particular ways. Each answer is assigned a value using a 5-point scale. The inventory is easy to understand and can typically be completed in less than 15 minutes. The KAI is one of the most highly validated psychological instruments in existence today. Supporting evidence for this claim may be found in the KAI Manual[6], which details the results of extensive testing and research studies using the instrument.

As shown in Figure 2, a person's overall KAI score will fall between 32 and 160, with a score of 32 representing the theoretical limit of highest adaption, and a score of 160 representing the theoretical limit of highest innovation. In practice, scores typically fall between 40 and 150. For large general populations, the distribution of scores forms a normal curve with a theoretical mean of 96. In the United States, the observed mean for the general population is 95, while the observed mean for both U.S. engineers and managers (measured separately) is 97. Additional statistics for these and other populations may also be found in the KAI Manual[6].

The KAI total score can be broken down into three interrelated sub-scores. The names and acronyms for these sub-scores are as follows: Sufficiency of Originality (SO), Efficiency (E), and Rule/Group Conformity (R/G)[5,6]. The SO sub-score relates to a person's style of idea generation, the E sub-score relates to one's method of problem solving, and the R/G sub-score relates to a person's style when dealing with structure, both impersonal (i.e., Rule) and personal (i.e., Group). While these sub-scores were determined for the ILTM students and faculty, they have not yet been fully analyzed and will not be reported here.

It is important to note once again that there is no correlation between KAI scores and any level measure. Thus, in this context, high scores are not "good" and low scores are not "bad"; it is the relative difference between the scores of two individuals or between an individual and the mean of a group that is important. In general, a difference of 10 points between individuals is noticeable over time. A difference of 20 points or more can lead to difficulties in communication and may require considerable *coping behavior*. Further discussion of coping behavior and its implications may be found in several of Kirton's works[3,4,6].

Administration of the Instrument

A qualified facilitator who has received the appropriate certification and training must administer and score the KAI forms. This certification process is tightly controlled to preserve the integrity of the instrument and prevent its misuse. Self-scorable and on-line forms are not available. Dr. Jablokow has received advanced training and certification in the instrument and was the sole administrator of the inventory in this study. The KAI forms were distributed to the students during an orientation session prior to the beginning of the program, but, as mentioned previously, they were not used in the actual design of the project teams for this study.

Reported KAI Scores

A summary of the ILTM students' total KAI scores is presented in Table 1 below. A few simple observations concerning this group of students as a whole can be made from these data. First, this group was slightly more adaptive than both the general U.S. population (mean of 95) and U.S. engineers and managers (means of 97), although the difference was not large in either case. Still, a difference of only 5 points between the means of two groups is noticeable over time, so differences in the behavior of this small cohort compared to a large group of engineers and/or managers might become significant after a prolonged period. Second, while the range of scores for the management students contains several of the most innovative scores in the entire group, the mean of the management students was almost identical to that of the engineering students.

Thus, we did not expect to observe any great cognitive style differences "between the disciplines" for this particular cohort of students.

There was also an interesting difference in the distributions of scores between male and female students from either discipline. While the most innovative student in the entire group was female, most of the more innovative students were male, resulting in a noticeably higher mean for the male students (95) as compared to the female students (88). This difference is mirrored in the general population, in which males' scores generally are normally distributed around a mean of 98 and females' scores around a mean of 91. Notice again the slight adaptive skew of these two gender-based subgroups as compared to the general population. The KAI scores for the four ILTM faculty members were diverse (63, 66, 104, and 124), with a mean score of 95.

SAMPLE	SIZE (N)	RANGE	MEAN
All Students	20	71 - 118	92
Engineering students only	9	72 - 107	91
Management students only	11	71 - 118	92
Male students only	11	78 - 109	95
Female students only	9	72 - 118	88

Table 1: KAI Scores for ILTM Students (2001)

As mentioned previously, the project teams were assembled in the traditional ILTM fashion for this study, that is, to maximize heterogeneity in gender, major, and GPA. As a result, the KAI profiles for the four teams had widely varying means and ranges, as shown below in Table 2. Note that Teams 1, 2, and 3 all have at least two individuals with a *cognitive gap* (i.e., difference in KAI scores) of more than 20 points, indicating potential "trouble spots" within those teams. Even the narrower diversity of problem solvers in Team 4 (range of 14 points) may experience problems with miscommunication due to cognitive style differences, according to Kirton's theory. Although not a significant factor in the results presented here, it is interesting to note that the assignment of the teams to the core faculty was such that Teams 1, 2, 3, and 4 were advised by faculty with scores of 66, 63, 124, and 104, respectively.

TEAM	KAI SCORES	RANGE	MEAN
1	71, 72, 87, 102, 105	34	87
2	94, 105, 107, 109, 118	24	107
3	73, 75, 78, 85, 99	26	82
4	83, 83, 93, 96, 97	14	90

Table 2: Project Team KAI Profiles

KAI Feedback Session

During the first week of the ILTM program, Dr. Jablokow delivered a one-day session that focused on basic Adaption-Innovation theory and its application in collaborative problem solving. The session opened with discussions of mental perception, barriers to effective problem

solving, and creativity myths and misconceptions. The fundamental assumptions of Adaption-Innovation theory were also presented, including (a) the difference between cognitive level and cognitive style and (b) the enabling and limiting roles of structure (see Kirton[5,6] for more on this Paradox of Structure). In the final segment of the morning session, the students received a feedback pamphlet with their individual KAI scores. These results were delivered confidentially, although the supportive environment established in the classroom encouraged most of the students to share their scores with each other immediately. No scores were divulged from any one individual to another without explicit permission, however, in keeping with the ethical administration of such an instrument.

During the afternoon session, Dr. Jablokow divided the students into groups based on KAI scores for several activities. First, four homogeneous groups (overall KAI scores within 10 points of each other) were formed, and each group was asked to identify in writing the advantages and disadvantages of having their particular score. Note that, in general, people having scores less than 10 points apart are generally regarded as having the "same" score, people having scores between 10 and 20 points apart are considered to have "similar" scores, and people with scores more than 20 points apart are said to have "different" scores. Students were then asked to meet in their project teams (which were generally more heterogeneous, as seen above) and to repeat the results of the first exercise with their teammates. Finally, each project team was asked to identify the challenges and benefits of having their specific KAI team profile. The students reported the results of both exercises to the entire ILTM group on large-format flipcharts.

The presentation styles used on the flipcharts alone gave strong indications of the KAI scores of the groups. In particular, when the students were in their homogeneous groups, the differences in the flipcharts were striking. The most adaptive group (KAI scores of 71, 72, 73, 75, and 78; mean of 74) presented their results in exceptionally neat columns in clear block lettering with very little extraneous information. The most innovative group (KAI scores of 105, 105, 107, 109, 118; mean of 109), on the other hand, presented their results in various colors, with arrows and annotations sprawled across columns, with various shadings and cross-hatchings, and generally in a much more free-flowing style. These observed differences, even in the style of presentation, are typical of those expected based on KAI scores.

Journaling Assignment

At the close of the KAI feedback session, the students were assigned a journaling project in which they were asked to record their impressions of their progress on their corporate projects and the ways in which the members of their respective teams interacted. A verbatim listing of this assignment is presented in Figure 3. Although journaling assignments are not always met with enthusiasm by students, most of the ILTM students wrote often, at length, and in detail throughout the course of the summer semester.

Institute for Leadership in Technology and Management

Bucknell University

Summer 2001

"Creative Thinking: Journal Assignment"

As part of Prof. Kathryn Jablokow's sessions on creative thinking and problem solving, a study is being conducted both of the adaption/innovation characteristics of this year's ILTM participants and of the interactions that arise between group members during this year's group projects. The Kirton Adaption/Innovation Inventory was in fact the form that was completed during the ILTM orientation session on April 19; the results from these forms and their interpretations will be discussed during Prof. Jablokow's session on June 14.

To measure and record group interactions during project work, all students are required to keep a journal documenting their experiences. Journal entries may be made either in an actual journal or electronically. All journals and computer files containing journal entries are to be submitted at the end of the summer semester.

Journal entries are to be made regularly but do not need to be of any particular length. A reasonable minimum amount of time to spend is 15 minutes per day, 5 days a week. For each entry, the time and date must be given. Specific areas that should be commented upon include:

- Overall progress of your work;
- Ways in which the tasks of your project have been divided among the members of your group;
- Particular difficulties/successes that your group has encountered/achieved;
- Ways in which the individuals of your group have contributed to the work and goals of your project;
- Specific ways in which the members of your group interact (whether they meet deadlines, follow instructions, come up with new ideas, "think outside the box," etc.);
- Ways in which your group interacts with its corporate liaisons and faculty advisor.
- Any overall "good" and/or "bad" experiences.

Be assured that all entries are completely confidential and will not in any way affect course grades. The entries will only be read by Prof. Jablokow and members of the ILTM core faculty and will not be discussed with other faculty or students. Although overall trends of both KAI scores and journal entries may eventually be published in a scientific journal, all results will be completely anonymous.

Figure 3: ILTM 2001 Journaling Assignment

5.0 Observations and Journal Excerpts

Observations gleaned from the ILTM students' journals can generally be organized into six categories, each focused on issues surrounding a particular theme, as follows:

1. Structure
2. Conformity and Consensus
3. Relevance
4. Conflict
5. Other Personality Factors (non-KAI)
6. Positive Value

It is interesting to note that the first three themes (structure, conformity, and relevance) can be related to the three KAI sub-scores mentioned earlier. A deeper analysis of this relationship will be undertaken in a future publication.

Structure

In general, we observed a direct relationship between Adaption and the level of frustration when dealing with ambiguity and incomplete information. That is, the more adaptive the student (the lower the KAI score), the more frustration they expressed when dealing with issues such as an open-ended project description, ambiguous tasks, and/or the inability to contact a corporate sponsor for further clarification. From the opposite perspective, the team with the most innovative KAI mean (Team 2) was only slightly bothered by a sudden midway switch in project direction (until later, when they realized how much work they had left to do). This is best illustrated by the following comment from the most innovative member of Team 2 (KAI score of 118): "Today was our field trip to Corning. I had a great time and thought it was very interesting. Andre and Mike were very helpful – although they did completely change our problem. That didn't really bother me because I wanted to do something on a more global level anyway … No one else in my group seemed to mind either." … (Two days later) "OK, I no longer feel glad that the project was switched. I am starting to realize how much we have to do and I feel really far behind."

Other issues concerning structure focused on different strategies for resource management, including the use of time. In particular, there was a direct relationship between Adaption and tighter time management, including planning ahead and being on time for meetings. As one of the more adaptive students in Team 3 (KAI 78) commented: "I am glad that we are more adaptive as a group. At this present time, the team needs more structure and direction rather than ideas. Assigning tasks is extremely important due to deadlines."

The more innovative students tended to be looser with their time management, and this difference extended into the use of meeting time itself. In addition, while the more adaptive students tended to bring structure to team meetings through note-taking and the sequential processing of information, the more innovative students reported less note-taking and were more inclined to "brainstorm" topics or use nonlinear processes such as mindmapping. There was also some evidence that the journal entries of the more adaptive students were more detailed.

Finally, the team with the most innovative mean and range (Team 2) also experienced some interesting difficulties that can be related to their preference for less structure. In particular, they experienced problems with boredom, lack of focus, and the inability to stay on task. All three issues are typical for more innovative individuals. Ironically, the members of this team expressed concern up front about the need for discipline in order to get their work done. Several team members tried to provide this discipline for the group, but their efforts were resisted, and they were not entirely successful. In the end, this team's results came together "at the last minute", with the bulk of the team handing off the details to one team member who was willing to deal with them.

Conformity and Consensus

We observed a direct relationship between Adaption and an emphasis on group conformity. That is, the more adaptive team members were more concerned about their team moving forward together and/or getting along, and they expressed the most frustration when this did not happen. An example of this concern came from a member of Team 1 (KAI 87): "I was happy that Student A (KAI 72) asked Student D and I after Student E had left if we thought she was doing enough work. It showed she cared about the team as well as evening out the workload."

We also observed a direct relationship between Innovation and the amount of work done independently, as opposed to full group work. That is, the more innovative students were more likely to work individually at first, bringing their results back to the team later for discussion. A student from Team 4 (KAI 83) made this comment, for example: "Today was a rough day for us as a group. It has become apparent that Student D (KAI 97) and Student E (KAI 93) are doing a lot of independent work, which is great for the group, but they did it without informing anyone else. It is not really an issue of leadership in my mind or Student A's (we talked about it together), however, it did bother us somewhat."

In related observations, the more innovative team members were perceived as being abrasive and occasionally even offensive in word and/or action. They were criticized for "having their fingers in everything", "bringing new ideas in at the end", "stepping on toes", and speaking up too much with faculty. On the other hand, the most adaptive members of two different teams were also perceived as offensive due to their "condescending" attitudes and tendency to reject the ideas of others.

Relevance

Several teams described issues surrounding the perceived relevance of the input from their more innovative team members. That is, the more adaptive team members did not always see value in the ideas of their more innovative teammates, who in turn felt that their work was disregarded and/or omitted with no good cause. The most innovative member of Team 3 (KAI 99) commented: "My group is starting to form better, but I still feel as though I am the person who fits in the least. Sometimes my ideas take longer to process and the longevity of this does not comply with the swiftness of my team members." Such division sometimes led the more adaptive team members to see their more innovative teammates as "refusing to join us", thereby

causing unwanted conflict within the team. Thus, issues with relevance eventually led to issues with conformity, demonstrating the complexity of cognitive style differences.

Conflict

In general, the greatest conflicts were associated in some way with the cognitive style extremes in a particular team. That is, conflicts were most often reported between the most adaptive team member and the most innovative team member, or between either one of these two and the rest of the team. As an example, the most innovative member of Team 2 (KAI 118) made the following observation: "Student A (KAI 94) and I disagreed several times, and I often felt that he was being condescending. Usually when I made a comment or suggestion, he would get defensive and didn't always listen to what I was trying to say. He would try to explain his way of doing things in a way that really bothered me at times." Later, after these two students had discussed their differences via electronic mail, Student A commented: "We were arguing the same thing, just from a different perspective."

It is interesting to note that the greatest amount of conflict overall was reported by the team with the largest cognitive gap, that is, the team with the largest range in KAI scores (Team 1). One team member noted: "For me it just seems emotionally draining when we meet as a group because I know we will not only have to tackle our GE assignment but also internal group struggles. Personally, I prefer not to work with Student B because his ways of thinking are so different from mine."

More homogeneous teams were not without their conflicts, however. One such team reported "in-fighting" among the most adaptive members of their team, who disagreed on how things should be done, that is, on the consensually agreed structure of the project. A member of Team 3 observed: "I also realized very quickly that if you are an adaptor, it does not mean you get along with all other adaptors." As mentioned previously, the most innovative team (which was fairly homogeneous) also reported conflicts as they tried to bring discipline to their efforts.

An interesting observation is the correlation between self-grading among group members and range of KAI scores. The students in the team with the smallest range of KAI scores (Team 4) all gave each other either an A or an A- on their project work. The students in the team with the second smallest range of KAI scores (Team 2) gave each other grades in the range of A to B. The students in the team with the second largest range of KAI scores (Team 3) gave each other grades in the range of A to C-. And the students in the team with the largest range of KAI scores (Team 1) gave each other grades in the range of A to F.

Other Personality Differences

Some of the interactions described in the students' journals led us to conclude that other individual differences might be at work here in addition to Adaption and Innovation. In particular, the journal data suggested that differences such as those described by Jung's psychological types (e.g., Introversion/Extraversion, Sensing/Intuition, Thinking/Feeling) might also be identified. Readers may be familiar with these preferences through the Myers-Briggs Type Indicator (MBTI), which also includes a fourth preference scale, Judging/Perceiving[7]. As

an example, a member of Team 3 made the following comment about another team member: "He often tells us how he feels and it is not very logical to me. I would rather hear the cut and dry facts than let emotions get in the way of our decisions." Other individual differences that seemed to affect team member interactions seemed to be linked to gender and major.

Positive Value

Despite the multiple sources of conflict, the students expressed real appreciation of each other's style differences as well. In particular, many of the more adaptive team members seemed to recognize value in their more innovative teammates bringing ideas to the table, ideas which they might not have devised on their own. As one more adaptive student commented: "It is not enough to know whether you are adaptive or not. What is important is the ability to bring your adaptive skills and be able to work with innovators to achieve the goal." Likewise, more innovative team members expressed appreciation for their more adaptive teammates' discipline and method in accomplishing tasks.

6.0 Conclusions and Plans for Future Work

This preliminary study has demonstrated that applying cognitive style theory to characterize and better understand the personal dynamics of students working in teams is both appropriate and useful. The data we collected suggests correlations between various cognitive styles and specific classroom behaviors, although these suggested relationships require further and more rigorous investigation. In addition, we were able to predict potential trouble spots due to conflicting styles. Perhaps most importantly, we were also able to convey an appreciation of different problem solving strategies to the students themselves.

The results of this study will be directly of use to the ILTM core faculty in formulating and advising project teams during the summer of 2002. In particular, in addition to using gender, major, and GPA to develop project teams, KAI scores will be factored into team assignments. KAI scores will also be used to form groups with either homogeneous or heterogeneous cognitive styles for group exercises within individual ILTM sessions. It is hoped that greater use of KAI scores will not only lead to the creation of more effective project teams but also to an even greater appreciation of creative styles by both faculty and students.

One limitation of the current study was the lack of measurements of other personality characteristics. A goal for the summer 2002 ILTM program is to administer both the KAI and another personality assessment instrument, such as the Myers-Briggs Type Indicator (MBTI). It is hoped that these two assessments will yield a more complete picture of the major factors affecting project team dynamics.

Plans are also being developed to work with one of the project sponsors to administer the KAI to a group of their most inventive researchers. The particular company under consideration has previously identified two general categorizations for such employees: "problem-collectors" and "solution-collectors." In brief, "problem-collectors" are those individuals who mentally collect and store the problems they encounter and are thus particularly well attuned to situations in which an apparent solution for one of these problems arises. "Solution-collectors" are

individuals who mentally collect novel solutions and are poised for the time when an appropriate problem is confronted. Our goal is to explore the correlations between these categorizations and Adaption-Innovation.

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