International Journal for the Scholarship of Teaching and Learning

Volume 3 | Number 1 Article 20

1-2009

Evaluation of Learning Style for First Year Medical Students

Mary Johnson
Indiana University School of Medicine, johnsomt@iupui.edu

Recommended Citation

Johnson, Mary (2009) "Evaluation of Learning Style for First Year Medical Students," *International Journal for the Scholarship of Teaching and Learning*: Vol. 3: No. 1, Article 20.
Available at: https://doi.org/10.20429/ijsotl.2009.030120

Evaluation of Learning Style for First Year Medical Students

Abstract

BACKGROUND. Many studies have documented the correlation of learning style and academic success for medical students. However, few have investigated the intersection of academic preparedness and students' preference for information processing. This study tested the hypothesis that learning style preference differs among medical students grouped by admission status. It also analyzed markers of academic success and their correlation with various learning styles. METHODS. First year students from six entering classes at one medical school regional campus were grouped into regular and alternate admission pools. All students completed two types of learning style questionnaire as a part of self-awareness training. RESULTS. Students from these distinct matriculant pools were found to have significant differences in multimodal, visual and kinesthetic learning styles. Both groups of medical learners were significantly different from the general population in several key learning characteristics, including sensing and judging dimensions measured using a version of the Myers-Brigs Type Indicator.

Keywords

Learning style, Sensing, Intuitive, Visual, Kinesthetic, Alternate admission

Evaluation of Learning Style for First Year Medical Students

Mary Johnson
Indiana University School of Medicine
Terre Haute, Indiana, USA
johnsomt@iupui.edu

Abstract

BACKGROUND. Many studies have documented the correlation of learning style and academic success for medical students. However, few have investigated the intersection of academic preparedness and students' preference for information processing. This study tested the hypothesis that learning style preference differs among medical students grouped by admission status. It also analyzed markers of academic success and their correlation with various learning styles. *METHODS*. First year students from six entering classes at one medical school regional campus were grouped into regular and alternate admission pools. All students completed two types of learning style questionnaire as a part of self-awareness training. *RESULTS*. Students from these distinct matriculant pools were found to have significant differences in multimodal, visual and kinesthetic learning styles. Both groups of medical learners were significantly different from the general population in several key learning characteristics, including sensing and judging dimensions measured using a version of the Myers-Brigs Type Indicator.

Keywords: learning style, sensing, intuitive, visual, kinesthetic, alternate admission

Introduction

Students who are accepted into U.S. medical schools via the regular selection process are chosen for their outstanding academic characteristics and are typically very similar to one another in this particular trait (Mavis & Doig, 1998). However, it is increasingly common for committees to decide in favor of students from a broad spectrum of backgrounds for admission to programs of study that lead to a doctorate in medicine (Hall, 1993). These students bring a wide variety of experiences to the study of medicine. Consequently, diversity in student approaches to learning would be expected in contemporary medical classrooms, more so than in the past, when the medical study body was more homogeneous. Another force that may contribute to a multiplicity of learning styles is the increase in class size planned by many medical schools in response to a call for more physicians. The Association of American Medical Colleges (AAMC) has projected a national shortage of physicians by the year 2020, due in part to the retirement of an aging professional workforce and a concomitant increase in the general population, in particular those over the age of 70 (Salsberg & Grover, 2006). A significant increase in the number of students admitted to U.S. medical schools naturally means a larger pool of successful applicants than in the past. Therefore, it is timely to consider the factors that contribute to high levels of academic achievement for learners outside the core of students traditionally selected for medical school admission.

Medical students face a distinctive challenge in the rigor of their required coursework and the increased volume that constitutes their program of study as compared to the university undergraduate curriculum (Lujan & DiCarlo, 2006). All medical students experience discomfort at some point during the training process (Dyrbye, Thomas, & Shanafelt, 2005). However, students from outside the regular admission applicant pool are more likely to face academic distress than students accepted from the mainstream of a traditional admissions process (Elam *et al*., 1999). Many of these students will come from targeted segments of the population that are underserved in the current healthcare environment (Salsberg & Grover, 2006). Conventional medical education strategies may not provide for the needs of these students as well as they have served traditional students in the past. Furthermore, student motivation and performance have been positively correlated with instruction that is adapted to their predominant learning preferences (Miller, 2001). Creative approaches that more closely match student learning styles could be used to great advantage in maximizing knowledge acquisition for individual students as the admissions pool is enlarged over the next decade. The goal of medical educators should be to create effective academic programs that support the success of all students who are invited to begin the lifelong process of medical training (Dyrbye, Thomas, & Shanafelt, 2005; Stewart *et al*., 1997).

These ideas are broadly applicable for learners across higher education levels. Each student who enters a given program of study will have a set of characteristics that encompass how information is taken in and processed (Kirby, 1979). Although cognitive style is a natural ability over which the learner has no influence, the learning style as defined by Kolb is more of a preference that can change over time as an individual develops experience (Kolb, 1984). Unique attributes like age, personality, temperament, and cognitive approach influence a given student's learning style, and this is true for learners in all disciplines (Kolb, 1984; Keirsey, 2000; Fleming, 1992). In one study of nursing students, those with a history of advanced coursework in physics, chemistry, mathematics or biology scored higher on tests of abstract conceptualization and problem solving than less prepared students (Sulliman, 2006). The learning style for the high-performing group was more direct, multimodal and visual than their counterparts, who preferred to listen and observe. Another study showed a strong correlation between abstract conceptualization measured using Kolb's learning style inventory and high scores on medical licensure examinations (Lynch *et al*., 1998). Conversely, Newland and Woelfl found a significant negative relationship between the concrete experience preference (kinesthetic learning style) and overall grade point average for early medical learners (1994). These studies provide evidence that learning style influences performance on standardized, objective measures of academic achievement. The results have important implications for curricular structure at a time when medical school enrollments are expanding (Rosenblatt *et al*., 2006). An enlarged student body can be expected to include more students with concrete, passive learning styles than in the past. An understanding of variations in learning style can inform changes in the teaching environment that may contribute to improved learning outcomes for under-prepared students (Dyrbye, Thomas & Shanafelt, 2005).

The Myers-Briggs Type Indicator (MBTI) has been employed in medical schools for nearly 40 years to establish profiles of student interactions with their environments (McCaulley, 1977; Pelley, 2006). The MBTI consists of a series of simple questions that reveal how learners process information to make decisions. Pelley's modified MBTI questionnaire consists of 28 forced-choice items that indicate a preference for 1) an active (extroversion, E) or reflective (introversion, I) approach to gathering information; 2) a fact-based (sensing, S) versus potential-focused (intuition, N) orientation to experiences; 3) either a thinking (T) or feeling (F) style, where objective and subjective disposition plays an important role, respectively;

and 4) a disposition for order and planning (judging, J) that contrasts with a spontaneous, flexible approach to learning (perceiving, P). An individual is assigned a four-letter learning style based on answers to the questions that sort into these four dimension-pairs. The method represents an effort to encapsulate the personality theories of Carl Jung into a psychometric instrument for learning preference (Jung, 1967; Myers & Myers, 1995). Sixteen potential learning style types can be identified using the MBTI. The categories can then be simplified by grouping into four fundamental temperaments using character descriptions based on Jungian typology theory (Keirsey, 1998). The method has been used in research on the education and career development of health professionals (Friedman & Slatt, 1988; Stilwell, 2000). A study was conducted with thousands of medical students in the 1990s to explore relationships between MBTI type and medical specialty choice (Stilwell, 2000). This data set was used for comparative purposes in our study in which the Pelley Learning Style Type Inventory was employed as the MBTI survey instrument.

The VARK learning style questionnaire is another method used extensively to measure several additional dimensions of learning. Developed by Fleming and Bonwell, the VARK is a tool that categorizes learning style according to Visual, Auditory, Read/write or Kinesthetic modes as indicated on a simple preference survey (Fleming, 1992). The VARK inventory provides insight into information processing preference, including the tendency for information acquisition through more than one learning mode simultaneously. The VARK inventory allows a four-point determination of learning preference to be made for a given student based on responses to 13 questions about orientation to information processing. People who score highest on the visual learning scale prefer to receive sensory information by seeing it, ideally in a graphical format. Auditory learners gather information best by hearing it presented. They deal best with facts, and prefer practical course materials and highly structured classes, including traditional didactic lectures. They are tolerant of repetitive learning strategies, but can be inhibited when instructional methods are taken out of context. Students who have their strongest result in the read/write dimension show a preference for information printed as words and may learn best through traditional methods like textbook- reading and lecture note- writing. Kinesthetic learners want concrete application and manipulation of the information they are receiving through experiments, discussions, or direct relevance. In the medical curriculum, case studies can be used to help these students apply content knowledge to clinical situations. The medical tradition of experiential learning is provided for kinesthetic learners through clinical rounds, laboratories, and cadaver dissections. Thousands of VARK determinations for college-aged students suggest that auditory and kinesthetic modes of learning predominate in the general population of college students (Fleming, 2007). This data was used for comparative purposes in our study of medical learners.

The present study uses a determination of learning style in medical education as a tool for student self-awareness as well as a source of information to guide curricular development. The educational setting was a regional medical campus with a small class size where data was gathered for first year students over six years in the early 2000's. Learning style was evaluated for first year medical students using both Pelley's Learning Style Type Inventory and the VARK learning style questionnaire. The students' learning style results were further grouped into four fundamental temperaments for additional investigation (Keirsey, 1998). These results were used to compare learners sorted by admission status and to contrast with a similar data set obtained using responses from a general U.S. population (Fleming, 2007). Subsequent to completing the two surveys, each student was provided with his or her personal results, and then participated in a group dialogue using aggregated class information as a prompt for conversation. Students discussed how individual variations can

be used constructively to enhance communication. As students understand more regarding their own orientation to learning, there is potential for them to develop insight into and respect for differences in others. This can result in real opportunities for self awareness and personal improvement. Each of these areas is fundamental to student growth in a profession where patients depend upon effective communication among healthcare providers with myriad personality styles, socioeconomic backgrounds and educational levels. In addition to providing information for students as a foundation for personal growth, we analyzed the survey results from several viewpoints as a guide to curricular reform. By understanding the implications of different approaches to learning, educators may consider presenting educational content in new ways. Effective teaching methods that address the diversity in learning style expected in future medical school classrooms could be developed. The cumulative effect of variety in programs of teaching and learning may better support students who are academically at-risk to achieve their professional goals.

Methods

For this study, we pooled the aggregated student data collected over a six year period into two groups to interpret the outcomes in a meaningful way. Students who were offered a position in the medical school entering class shortly after applying and completing the interview process constituted the regular admissions group. Students who were admitted later, after a period of time on a "wait list" of alternate candidates, constituted the alternate list group. Statistical analysis was performed using SPSS 14.0 for Windows XP. Institutional review board approval was provided for all work reported in this study (IRB #EX0610-28).

Learning style was identified using the VARK online inventory developed by Fleming (1992). Between 2000 and 2005, 74 first year medical students completed the self-scoring VARK inventory (87% of the students who matriculated at one regional campus). Each student could select multiple responses for each of 13 questions. Students reported their results electronically as a part of a self-awareness activity. Results were tallied for each of the learning modalities (V, A, R, and K) and/or combinations of modalities with a total of 109 responses used in the calculations. Students who had a minimum score of 4 in several categories reported multimodal learning (44.6% of all responses for n=74). The most common pattern was bimodal learning, with two dominant styles. Bimodal styles distributed with a 0.5 value for further analysis. For three modes, each was assigned a 0.3 value. A 2x4 factorial analysis of variance for independent samples with standard weighted means was used to analyze statistical significance between single VARK types and multimodal style. Post hoc analysis was performed using a one-tailed, unpaired *t*-test. Responses to the VARK inventory from 56,145 English-speaking students were used as expected values to compare with our medical student results. The significance level was computed as a 2x2 Chi-square with one degree of freedom, calculated separately for each comparison.

The Pelley Learning Style Type Inventory used in the study consisted of 28 forced-choice items: nine for the sensing-intuitive dimension, five for the thinking-feeling dimension, and seven each for the extravert-introvert and judging-perceiving dimensions. Four-letter types for aggregated student responses were analyzed for statistical significance using a Selection Ratio Type Table Program developed by the Center for Applied Psychological Type. The program calculates the significance for each index using a 2x2 Chi Square with one degree of freedom. For some cells in the Type Table the numbers do not meet the requirements for calculating Chi-Square and the program reports a Fisher's Exact Probability.

Results

Aggregated student data collected over a six-year period were pooled into two groups. In Fig. 1, single VARK responses were plotted along with "multimodal" as a learning style where no dominant information processing style was indicated. Regular admission students were more likely to have a multimodal learning style (52.4%) than students admitted from the alternate list (34.4%) and they were nearly twice as likely to learn from visual sources (11.9% vs. 6.3%). The groups were similar in read/write data processing, but twice as many alternate list students indicated a kinesthetic learning style. In addition, an auditory-dominant learning mode was prominent for students admitted through the alternate route (12.5%) but entirely absent as a single mode learning style for regular admission students.

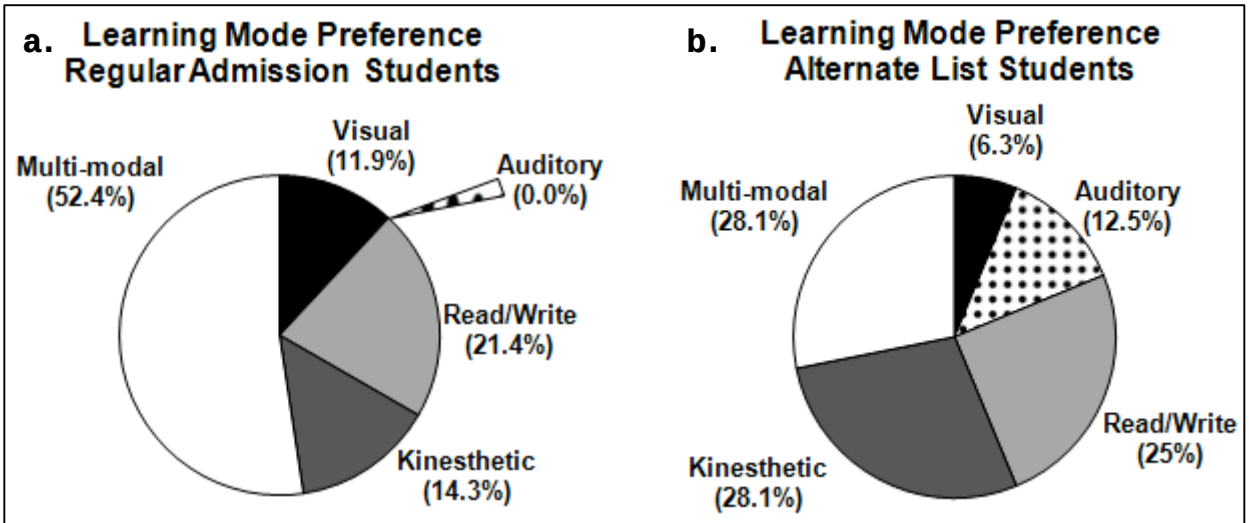

Figure 1. VARK inventory results for first year medical students from two distinct groups based on admission status. The n= 74 students, 32 from the alternate list (a) and 42 selected through regular admission (b). A 2x4 factorial ANOVA showed significant differences between VARK categories ($F=14.85$ with 3 df and $p<0.0001$) with a significant interaction effect between admission status and learning mode ($F=4.39$ with 3 df and $p=0.005$). Post hoc *t*-test values were $p<0.05$ for Auditory and Multi-modal learning.

In Fig. 2, single responses from our study (V, A, R, or K responses summed using fraction distributions for multi-modal) were plotted by admission group, along with a 2005 data set for English-speaking survey participants collected on the VARK website. Medical students from the alternate list (n=32) were similar to the general population in visual, auditory and kinesthetic comparisons (p=0.343; no significance). For regular admission students, p<0.005 (n=42) for each of these categories. Both medical student groups showed greater read/write preference than the general population, but differences were not significant.

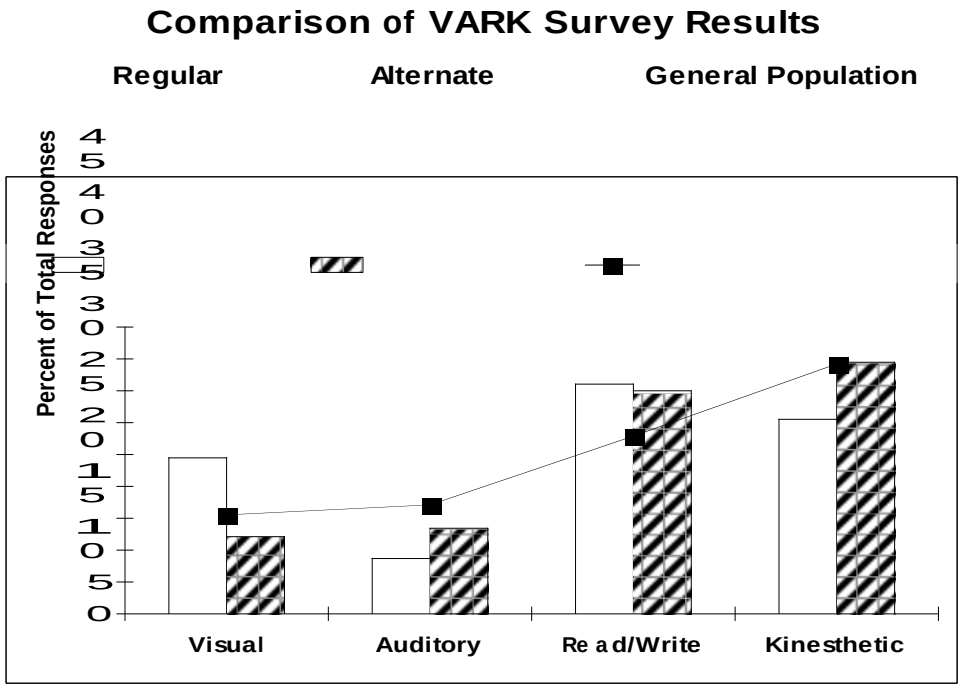

Figure 2. VARK inventory results for first year medical students compared with students from the general population. Students admitted from the alternate list (n=32) are similar to the general population (n=56,145) in overall VARK responses. Statistical significance was computed as a 2x2 Chi-square with one degree of freedom, calculated separately for each comparison. For visual, auditory and kinesthetic tests, p<0.005 for regular admission (n=42); alternate list vs general population, p=0.343.

Several indicators of future academic performance were used to substantiate the grouping of students to analyze the impact of learning style. Table 1 compares the two student groups shown in Fig. 1 and 2 using two-tailed, unpaired *t*-tests for several academic parameters including the Medical College Admissions Test (MCAT), undergraduate grade point average (GPA), and the first U.S. Medical Licensure Examination (USMLE Step I). Each summary statistic was converted to a Z-score, allowing direct comparisons to be made across parameters. Differences in pre-admission indicators of academic performance for the two student groups were highly significant statistically (p<0.0001) and remained significantly different through completion of the first licensure examination during medical school (p<0.05). Differences between the groups were not significant for the USMLE Step II, the medical licensure exam administered prior to residency training (p=0.201, data not shown).

Table 1. Summary of Medical Student Academic Statistics

Admission Category	MCAT Z-Score	Undergraduate GPA Z-Score	USMLE Step I Z-Score
Regular Selection Students (n=42)	0.37	0.33	0.15
Alternate Selection or Wait-Listed Students (n=32)	-0.49	-0.44	-0.15

Critical academic indicators were compared for the groups shown in Fig. 1 and 2 using a two-tailed, unpaired *t*-test. Differences in MCAT test Z-scores and GPA Z-scores were highly significant ($p<0.0001$). The difference in USMLE Step I Z-score was significant at the 0.95 confidence interval ($p<0.05$).

Table 2 shows the sixteen MBTI types determined from results using the Learning Style Type Inventory. We compared data for the first year medical students described in Fig. 1, Fig. 2, and Table 1 with base source data on 3,987 medical students who graduated between 1983 and 1995 (Stilwell *et al*., 2000). The greatest differences in type were found for "SJ" and "SP" types (indicated by *** in Table 2). Our first year students indicated the "SJ" type at significantly higher levels than those reported for the base source group of medical respondents. The first year students in our study also indicated the "SP" type at much lower levels than for students reported in the literature. This held true for both the base source medical students from the early 1990's (Stilwell *et al*., 2000) and for medical students described in an earlier study (Myers & Myers, 1995).

Table 2. Type Preferences for First Year Medical Students

COMPLETE TYPE	ISTJ	ISFJ	INFJ	INTJ
Percent of Total	21.43%	15.71%	2.86%	7.86%
Self-Selection Index	I = 2.1***	I = 2.5***	I = 0.5	I = 1.04

COMPLETE TYPE	ISTP	ISFP	INFP	INTP
Percent of Total	7.86%	2.86%	3.57%	1.43%
Self-Selection Index	I = 2.61**	I = 1.48	I = 0.47	I = 0.2

COMPLETE TYPE	ESTP	ESFP	ENFP	ENTP
Percent of Total	2.86%	7.14%	3.57%	0.71%
Self-Selection Index	I = 0.93	I = 3.16***	I = 0.39	I = 0.11

COMPLETE TYPE	ESTJ	ESFJ	ENFJ	ENTJ
Percent of Total	13.5%	5.0%	2.14%	1.43%
Self-Selection Index	I = 1.41	I = 0.79	I = 0.35	I = 0.19

Local sample data set compared with base source data from Stilwell, *et al*. (2000). **$p<0.05$ and ***$p<0.001$.

Fig. 3 compares the MBTI type preference results for the each of the regular admission and alternate admission learner groups defined in our study with Keirsey temperaments described for the general population. Data for the general population were derived from information available on the Keirsey temperament website [http://www.keirsey.com/ and described by Keirsey, (2002)]. Significant differences were found for medical student learning style results analyzed in this report and those described by Keirsey for the general population. Similar to the results documented in Table 2, the "SJ" and "SP" types were again of greatest interest in this analysis.

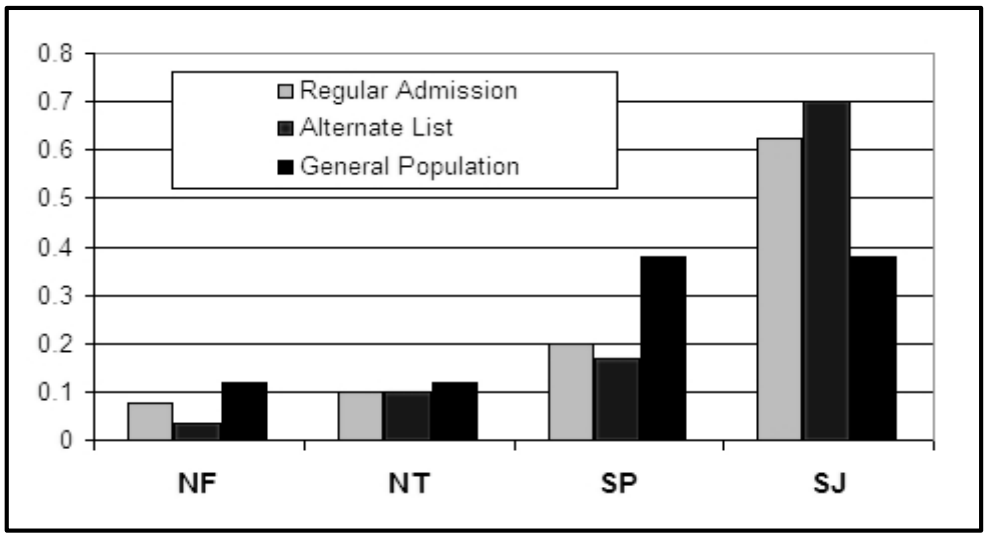

Figure 3. MBTI results for first year medical students compared with students from the general population. Students admitted from both the alternate list (n=32) and regular admission (n=42) are significantly different from the general population in temperament (SP= Keirsey's "Artisan" and SJ= Keirsey's "Guardian" temperament). Significance level was computed as a 3x4 Chi-square with 3 df (17.38; $p<0.001$).

The implications of learning style analysis results are typically noteworthy for the teaching of any given cohort of students. For every learning style preference there are both advantages and problems associated with any given instructional mode. Dunn & Dunn (2003) suggest that students whose learning styles are accommodated by curricular components can be expected to achieve much higher levels on standard performance measures than students who have not benefited from instructional methods that complement learning style. Lin *et al*. (2005) suggest that adult learners with distinct learning preferences gravitate towards corresponding styles of information presentation. In the current study, we found that students who matriculated from the alternate list had significantly different learning modes in several key areas from traditional, regular admission medical students. First, they are less likely to have a preference for multimodal learning than traditional medical students (Fig. 1). The prevalence of a single, dominant, learning approach for students within the alternate group may presage the need for a curricular structure using varied opportunities to accommodate optimal learning using these modes. Such a teaching strategy may address the needs of students who experience academic challenge better than more traditional classroom structures. The larger number of auditory learners in the alternate group compared with traditional medical students is particularly striking. Among regular admission students, not a single person indicated a dominant auditory mode, compared with 12.5% single mode auditory learners among the alternate list students. Didactic lectures may be of great use for auditory-dominant learners, a point that is counter-intuitive to the current trend for decreased emphasis on this format (Barber, 2007; Skidmore, 2006). There is some evidence that the impersonal nature of lecture settings is the counterproductive factor (Davis, 2007). Creative methods such as the electronic audience response system may enhance the time-honored lecture tradition by integrating interactive elements, while retaining the essential auditory learning dimension (Draper & Brown, 2004). Efforts to provide podcast and audio file recordings also may prove useful for students with an auditory-dominant learning styles.

When each of the four learning style modes is examined individually, as in Fig. 2, the alternate list students tested in this study seem much more like the general population in their approach to learning than regular admission medical students. They indicated a stronger preference for kinesthetic learning, a pattern that differs from the traditional medical student group ($p<0.005$), but is similar to learners from the general population who choose more often to "learn by doing" ($p=0.343$). Fig. 2 also reinforces the notion that many students in the general population find auditory learning to be an effective means for acquiring information. Auditory learning remains a fruitful strategy among students who have a greater level of academic challenge. However, as shown in Fig. 1, auditory learning was tallied only as one aspect of a multimodal learning process for traditional medical students, and not designated as a dominant modality by a single high-performing student who was selected through the regular admission process.

Visual learning mode was another area where the students in our study groups showed major differences. The alternate list learners were less likely to signify a preference for learning through presentations of visual information than typical medical students. This was enlightening since many educators assume that visual learning materials will be more generally useful than indicated by our findings. Visual materials for medical learning such as diagrams, photographs, and video clips that demonstrate procedures may not be effective for at-risk learners as intended by the educator. Conversely, courses that utilize manipulation, interaction, and active learning may have a greater likelihood of benefiting learners who experience academic challenge. This may be a generalizable concept, since one study of statistical education outcomes has shown that cooperative learning may be especially useful for students who prefer to learn by kinesthetic means (Boyd, 2002). The ongoing success of anatomy dissection laboratory experiences, even though the cost remains high and image-based alternatives are available, supports this notion (Netterstrom & Kayser, 2008). On a negative note, the movement away from direct manipulation of laboratory materials in medical courses like microbiology, biochemistry and pathology may have an unintended negative impact on learning in those disciplines. And finally, many studies suggest that computer-assisted learning supports students who have concrete, practical learning styles, due in part to the tactile, kinesthetic keyboard interface (Johnson, 2008; Cook, 2005a).

The trends in learning style identified for alternate list students in this study may be a crucial finding since indicators of academic preparedness for these students were significantly different than for other students tested (Table 1). Z-scores for the medical school entrance examination (MCAT) and the undergraduate grade point average were lower for alternate list matriculants, and this difference persisted during medical school as indicated by aggregated Z-scores for the USMLE Step I licensure examination (Table 1). One positive development for medical curricula that may enhance opportunities for such at-risk students is team-based learning (TBL). The TBL strategy was first developed for the undergraduate university environment and it is increasingly employed for medical education (Michalesen, *et al*., 2003). TBL is arranged in groups where attendance is encouraged by increasing the individual's sense of responsibility to the team. Interactions with other students and in-depth application of new concepts may favor learners who prefer the kinesthetic and auditory styles employed during the team process. In our study, the small group setting of a regional campus may contribute to academic success for at-risk students because significant differences between matriculant groups disappeared by the end of medical school. The small class size makes responsiveness to individual student needs a more reasonable undertaking than in settings with larger class sizes. TBL can be used to

equivalent effect, even in settings where a large class size might seem to preclude this strategy.

The VARK inventory deals with only one of nearly twenty dimensions of learning, that of information intake and information delivery. It has little to offer in the areas of personality or social preference (Fleming, 2007). Taking the type preferences of students into account using the MBTI instrument provides insight into several additional learning dimensions. The MBTI is based on Carl Jung's theories about personality type (for a review, see Peters, 1993). Along with a basic tendency of introversion or extroversion, Jung differentiated between sensing-intuition (S-N) and thinking-feeling (T-F) personality types. Myers and Briggs added the judging-perceiving (J-P) attributes to arrive at a four-letter combination that describes overall personality (Deuschle, 2001). Although not as reliable as the MBTI personality type test on which it is modeled, the Pelley Learning Style Type Inventory has been validated for the S-N dichotomy that was determined to be the most significant dimension for the current study (Cook, 2005b).

We analyzed type data for all medical students taught during a ten-year period at this regional campus to enable greater insight into the variables that may influence academic performance (Table 2; n=140). The base data for comparison was a larger set of responses from 3,987 medical students tested using the MBTI in the 1990's (Stilwell *et al*., 2000). For the J-P dimension, there has been a shift away from the observation of perceiving types as predominant among medical students from the 1950's in the landmark study by Isabell Briggs-Myers (Myers & Myers, 1995). A prevalence of judging types was indicated in the current sample of medical students, even more prominent than in the Stilwell *et al*. study (2000). The T-F dimension was another area of departure from the earlier study where feeling types were in the majority (46% thinking preference). For both the medical students in the current study and the Stilwell *et al*. sample a greater preference for the thinking type was indicated (55% and 57%, respectively). This trend may be a reflection of the increasing pervasiveness of technology in the lives of current students and in the practice of medicine.

The sensing-intuition dimension most closely concerns the patterns a student uses to filter information from the environment. That is the dimension where our student population differed most from medical students who were tested in previous decades. Sensing is defined as the collection of information from the surroundings through sights, sounds, or tactile interactions (Peters, 1993). A significantly larger proportion of medical students in our study indicated the "SJ" type preference (see Table 2, row one, $p<0.001$). The "SJ" type is described by Keirsey as "The Guardian": rigid; oriented to concrete detail; and possessed of a self-confident and aggressive style (Keirsey, 1998). Previous studies concerned with MBTI type and specialty choice among medical graduates showed correlations between "SJ" type and choice of family practice specialty, where rugged independence is a necessity (Myers & Myers, 1995; Stilwell *et al*., 2000).

Learners may have a greater tendency to interject values and beliefs into the process for gathering information when sensing is combined with perception (the "SP" or "Artisan" Keirsey temperament). The "SP" types were underrepresented among medical students in our sample as compared with medical students from the larger base data set (Table 2). When compared with the temperaments found among the general population (Fig. 3), the "SP" student groups in our study were much lower in proportion than those reported by Keirsey (1998).

The "ST" types were the most predominant MBTI types found among medical students in our study (Table 2, rows one and two; $p<0.001$). When sensing is combined with thinking (ST), the individual is mainly concerned with assembling facts that can be validated or authenticated. Persons having the "ST" profile are strong in linear reasoning, but have a harder time grasping the big picture and applying the abstract critical thinking skills necessary to integrate patient case information. This tendency has important implications for teaching and learning strategies.

The S-N dichotomy has been emerged as the type preference dimension of greatest impact for medical learning outcomes before (O'Donnell, 1982). Thirty years ago, entering medical students were predominantly male (69%), and uniformly grounded in scientific disciplines that require abstract thought (AAMC, 2008). More than half of the students tested at one southwestern medical school indicated the intuition type preference (O'Donnell, 1982). Intuitive individuals become aware of information in an indirect way, filtering facts through reference to experience then developing a framework for understanding (Deuschle, 2001). In our study, gender among the medical student population was more balanced (56% male), but those who indicated an intuitive type preference were now clearly in the minority at 24%, regardless of admission category. Students with intuitive learning styles are best served when they are able to apply new information to specific situations, like clinical cases. This is a critical skill for physicians-in-training to acquire, and it is a challenge to nurture the development of intuitive skill in students with the opposite learning temperament. The majority of the students in our study indicated the sensing type (Table 2: 76% "SP" or "SJ" temperament), but in a distribution opposite to that found in the general population (Fig. 3). Sensing students have a natural tendency for learning the details surrounding a deep understanding of multiple medical disciplines, but face more difficulty in applying concepts within the context of the "big picture". Providing students with opportunities to appreciate both learning approaches can encourage integrative thinking in conjunction with content mastery.

Implications of the Present Study

Because the AAMC has projected a national shortage of physicians in the U.S. by 2020, a significant increase in the number of students admitted to medical school has been recommended for classes in the near future. It is unlikely that applications to medical schools will increase to meet this need. Therefore, it will be necessary to admit a greater number of students from what has previously comprised an alternate applicant pool. Students are generally assigned this status based on a lower grade point average and/or lower MCAT scores than students admitted from the mainstream of regular applicants. We found that the regular admission medical students tested in this study were significantly different from the general population in their learning styles, but that alternate admission students were more similar to the general public than to their more traditional peers. By extrapolation, when medical schools expand to produce more physicians, there is an increased likelihood of diversity in student learning styles than observed in the past. It is expected that some of the students in the enlarged applicant pool will come from non-traditional or underserved backgrounds (Elam *et al*., 1999). Students from these demographics are likely to face academic challenges and it is therefore prudent to anticipate their needs. This suggests that a more complete understanding of student learning styles would support faculty members who are interested in expanding learning opportunities. Aligning instructional offerings to student learning styles is one tactic that may serve to improve the learning environment for at-risk students. This concept is generally applicable

for students at any point in the continuum of university-level education. Conventional educational strategies may serve high-performing learners better than students who are struggling.

In addition to forces that are driving program expansion, curricular reform at some medical schools has resulted in more independent and unstructured learning time for medical students. This approach may also be a better fit for students with the learning styles predominant among high-performing students (Borges, *et al*., 2006). Again, a method of instruction that complements the learning styles of at-risk student is worth considering. TBL with its emphasis on reading, matches the read/write learning style preference found among alternate list students in our study. Students are required to read a short set of structured materials in preparation for a quiz given within a group setting. The kinesthetic learning style predominant among at-risk learners may also be reinforced by group dynamics as well as through laboratory-based courses like human gross anatomy. Therefore, it may be critical to retain additional experiential learning environments like medical histology and medical microbiology, where laboratory-based manipulations and microscopy can be used to reinforce concepts derived from lectures.

Conclusions

Learning style preference was examined in this study of differences among medical students admitted by regular versus alternate selection processes in a multiyear grouping from one midwestern medical school. Students selected from these distinct applicant pools were found to have significant differences in multimodal learning style, visual learning and kinesthetic learning. Awareness of student learning style and personality type could provide a basis for instructors to optimize teaching methods for diverse student populations.

Learning style diversity, when properly understood by both students and educators, can be converted into appropriate teaching and learning methods that enable more students to attain success. In an era of constrained resources coupled with increased public demand for highly trained professionals, educators will be faced with the need to find effective ways to assist students who are at-risk for achievement of their academic goals. This quest can be facilitated by identifying how learners perceive, interact with, and respond to the learning environment. Tools like the VARK and MBTI inventories described here can easily be used for this purpose. Such analyses can inform students about their own learning processes, and can also encourage them to draw upon learning opportunities designed to match their unique styles. This approach has the potential to enhance the capacity of at-risk students to process complex information, to nurture their development as critical thinkers, and to improve their overall academic performance. Curricular elements that may enhance learning for students who experience academic challenge include team-based learning, recorded lectures, audience response systems, and internet-based materials. Web-based instruction in particular is an emerging technique that can be exploited to combine auditory and visual learning with reading and kinesthetic tasks (Johnson, 2008; Cook, 2005a). Methods that intentionally combine information processing across learning styles may have the greatest potential for supporting academic success for more students.

Acknowledgment. I would like to thank Jamie Johnson at the Center for Applications of Psychological Type for her assistance in running the MBTI Selection Ratio Type Table

Program. I would also like to thank the anonymous IJ-SoTL reviewers for their helpful suggestions and feedback.

References

Association of American Medical Colleges (2008). U.S. medical school applicants and students 1982-83 to 2007-08. AAMC Data Warehouse. Washington, D. C.

Barber, M. (2007). Reassessing pedagogy in a fast forward age. *International Journal of Learning, 13*(9): 143-149.

Borges, N., Manuel, R. S., Elam, C. L., & Jones, B. J. (2006). Comparing millennial and generation X medical students at one medical school. *Academic Medicine, 81*(6), 571-576.

Boyd, F. T. (2002). Methods of learning in statistical education: design and analysis of a randomized trial. Dissertation, Johns Hopkins University. Retrieved 12-15-07 from *Statistics Education Research Journal*, http://www.stat.auckland.ac.nz/~iase/publications/dissertations/02.Boyd.pdf

Cook, D. A. (2005a). Learning and cognitive styles in web-based learning: Theory, evidence, and application. *Academic Medicine, 80*(3), 266–78.

Cook, D. A. (2005b). Reliability and validity of scores from the index of learning styles. *Academic Medicine, 80*(10), S97-S101.

Davis, J. (2007). Dialogue, monologue and soliloquy in the large lecture class. *International Journal of Teaching and Learning in Higher Education, 19*(2), 178-182.

Deuschle, W. F. (2001). Myers-Briggs-Jung psychological type theory reformulated as a cognitive socio-psychological theory of type. *Journal of Psychological Type, 57*, 18-24.

Draper, S. W. & Brown, M. I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning, 20*(2), 81-94.

Dunn, R. & Dunn, K. (2003). The Dunn and Dunn learning style model: Theoretical cornerstone, research and practical applications. In S. Armstrong, M. Graff, C. Lashley, E. Peterson, S. Raynor, E. Sadler-Smith, M. Schiering & D. Spicer (Eds.) *Bridging theory and practice.* Proceedings of the Eighth Annual European Learning Styles Information Network Conference, University of Hull, Hull, UK

Dyrbye, L. N., Thomas, M. R. & Shanafelt, T. D. (2005). Medical student distress: Causes, consequences, and proposed solutions. *Mayo Clinic Proceedings, 80*(12), 1613-1622.

Elam, C. L., Wilson, J. F., Johnson, R., Wiggs, J. S., & Goodman, N. (1999). A retrospective review of medical school admission files of academically at-risk matriculants. *Academic Medicine*, 74(10), S58-61.

Fleming, N. D., & Mills, C. (1992). Not Another Inventory, Rather a Catalyst for Reflection. *To Improve the Academy, 11*, 137-143.

Fleming, N. D. (2007) VARK: A guide to learning styles. Retrieved 11-15-07 from http://www.vark-learn.com/english/page.asp?p=questionnaire

Friedman, C. P. & Slatt, L. M. (1988). New results relating the Myers-Briggs Type Indicator and medical specialty choice. *Journal of Medical Education, 63*: 325-327.

Gardner, H. (1993). *Multiple intelligences: The theory in practice.* New York: Basic Books.

Hall, F. R. (1993). *Survey on medical school admission practices.* Washington, D.C.: Association of American Medical Colleges Group on Student Affairs, 1993.

Hawk, T. F. & Shah A. J. (2007). Using learning style instruments to enhance student learning. *Decision Sciences Journal of Innovative Education, 5(1),* 1–19

Johnson, M. T. (2008). Impact of online learning modules on medical student microbiology examination scores. *Journal of Microbiology and Biology Education, 9*, 25-29.

Jung, C. G. (1967). The development of personality. *Collected Works Vol. 17* (1991 ed.) London: Routledge.

Keirsey, D. (1998). *Please understand me II: Temperament character intelligence.* Del Mar, CA: Prometheus Nemesis Book Company.

Keirsey, D. (2002). *People patterns: A modern guide to the four temperaments.* Del Mar, CA: Prometheus Nemesis Book Company.

Kirby, P. (1979). *Cognitive style, learning style and transfer skill acquisition.* The Ohio State University, Columbus, OH: National Centre Publications.

Kolb, D. A. (1984). *Experiential learning*. New Jersey, USA: Prentice Hall

Lin, L., Cranton, P. & Bridglall, B. (2005). Psychological type and asynchronous written dialogue in adult learning. *Teachers College Record Volume, 107(8)*: 1789-1813.

Lujan, H. L. & DiCarlo, S. E. (2006). First-year medical students prefer multiple learning styles. *Advances in Physiological Education, 30*, 13-16.

Lynch, T. G., Woelfl, N. N., Steele, D. J. & Hanssen, C. S. (1998). Learning style influences student examination performance. *American Journal of Surgery, 176,* 62-66.

Mavis, B. & Doig, K. (1998). The Value of noncognitive factors in predicting students' first-year academic probation. *Academic Medicine, 73*, 201-203.

McCaulley, M. H. (1977). The Myers longitudinal medical study: Monograph I. In *Application of the Myers-Briggs Type Indicator to medicine and other health professions.* Gainesville, FL: Center for Application of Psychological Type.

Michalesen, L. K., Knight, A. B. & Fink, L. D. (2003). *Team based learning: A transformative use of small groups.* Westport, CT: Praeger.

Miller, P. (2001). Learning styles: the multimedia of the mind. *Educational Resources Information Center ED, 451*, 140.

Myers, I. & Myers, P. (1995). *Gifts differing: Understanding personality type*. Mountai View, CA: Consulting Psychologists Press.

Netterstrom, I. & Kayser, L. (2008). Learning to be a doctor while learning anatomy! *Anatomical Sciences Education, 1*(4), 154-158.

Newland, J. R. & Woelfl, N. N. (1992). Learning style inventory and academic performance of students in general pathology. *Bulletin for Pathology Education, 17*, 77– 81.

O'Donnell, M. J. (1982). NBME Part I examination: possible explanations for performance based on personality type. *Journal of Medical Education, 57,* 868-870.

Pelley, J. (2006). The success types learning style type indicator. Retrieved 9-15-06 from http://www.ttuhsc.edu/SOM/Success/LSTIntro.htm

Pelley, J. W. & Dalley, B. K. (1997). *Success types for medical students.* Retrieved from http://www.ttuhsc.edu/SOM/success/

Rosenblatt, R. A., Andrilla, H. A., Curtin, T., & Hart, L. G. (2006). Shortages of Medical Personnel at Community Health Centers. *Journal of the American Medical Association 295*: 1042-1049.

Peters, D. C. (1993). Forever Jung: Psychological type theory, the Myers-Briggs Type Indicator and learning negotiation. *Drake Law Review, 42(1)*, 1-121.

Salsberg, E. & Grover, A. (2006). Physician Workforce Shortages: Implications and Issues for Academic Health Centers and Policymakers. *Academic Medicine 81(9)*, 782-787.

Skidmore, D. (2006). Pedagogy and dialogue. *Cambridge Journal of Education*, *36*(4), 503 514.

Stewart, S. M., Betson, C., Lam, T. H., Marshall, I. B., Lee, P. W., & Wong, C. M. (1997). Predicting stress in first year medical students: A longitudinal study. *Medical Education* 31: 163–168.

Stilwell, N. A., Wallick, M. M., Thal, S. E., & Burleson, J. A. (2000). Myers–Briggs Type and medical specialty choice: a new look at an old question. *Teaching and Learning in Medicine 12*(1), 14–20.

Suliman, W. A. (2006). Critical thinking and learning styles of students in conventional and accelerated programs. *International Nursing Review*, *53*(1), 73-79.