Gregorc (1) developed the GSD as a psychometric instrument to determine an individual's "mind" style. This instrument is based on mediation abilities theory, which states that the human mind contains channels through which information is received and expressed in an efficient and effective manner. There are two types of mediation abilities, perception and ordering.

Perceptual ability deals with how an individual receives information. Gregorc (1) claims that perception can be described on a continuum as abstract vs. concrete. Abstract ability enables information interpretation by use of reasoning and involves intuition to deal with subjective concepts and feelings. A person using abstract reasoning can perceive information that is invisible to the physical senses. On the other hand, concrete ability enables an individual to interpret information that is gathered by the senses, such as visual, auditory, and tactile stimuli, and to apply this information to the physical world.

Ordering ability deals with how a person arranges and uses information. Gregorc (1) claims this ability is described on a continuum as sequential vs. random. Sequencing is used to organize data in a linear fashion, which enables precise, progressive, and logical communication. Random processing of information occurs in a netlike fashion with a myriad of interrelated information. Random processing enables an individual to deal with diverse pieces of information simultaneously.
The GSD test booklet developed by Gregorc (2) has combined the mediation abilities into four distinct mediation channels or mind styles: abstract random (AR), abstract sequential (AS), concrete random (CR), and concrete sequential (CS). These mind styles are alleged to form two bipolar scales consisting of CS vs. AR and AS vs. CR. Although Gregorc used the GSD to identify an individual’s mind style, several users of the instrument associate mind style with learning styles (7). On the basis of Gregorc categories, individuals who are CS learners tend to process information in a methodical, instinctive, deliberate manner, whereas CR learners tend to process information in an intuitive, impulsive, and independent manner. However, AS learners tend to process information in an intellectual, analytic, logical, and correlative manner, whereas AR learners appear to process information in an emotional, perceptive, and critical manner.

The GSD ranks a series of matched word associations in a word matrix and assigns a numerical value to each of the four learning styles. The learning style with the largest number assigned to it is identified as the dominant style employed by an individual. Wells and Higgs (7) employed the GSD to determine preferred learning styles for nursing students in the first and fourth years of their program and concluded that the majority of students were either AR or CS. The main objectives of the present study were to determine the dominant learning style in a class of nursing students by use of the GSD and to determine whether certain learning styles allegedly identified by it can be associated with enhanced performance on achievement tests in a human anatomy and physiology course.

METHODS

The GSD was administered to 283 nursing students enrolled in Medical Science (MDSC) 200, an introductory first-year course in human anatomy and physiology offered annually by The University of Calgary, Faculty of Medicine to students enrolled in the Faculty of Nursing. The course is divided into two semesters, with a total of 150 hours of instruction. The course topics within each semester differ and are organized according to different body systems. Instruction is provided using a multidisciplinary team teaching approach. Lectures are supplemented with structured laboratory sessions that provide students the opportunity to view prepared human specimens and to relate the theoretical aspects of the lecture material to the human body. Student achievement in MDSC 200 is assessed by four examinations (two midterms and two end-of-semester examinations) covering lecture content and two laboratory examinations, which are more anatomic in nature. The final grade is based on a single score, calculated as a weighted combination of the raw scores from the six examinations. Student examinations are prepared by selecting questions, developed by the course instructors, that are stored in a computerized test bank. During the academic year a total of 23 students withdrew from the course. Only the 260 students completing the entire course were used to analyze the relationship between learning style and achievement in the course.

RESULTS

Table 1 summarizes the results from the GSD administered to the nursing students. The dominant learning styles used by the students were identified using the mean values for each learning style. The results
TABLE 1
GSD class profile for 260 nursing students in MDSC 200

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>GSD Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>26.148 ± 0.303</td>
</tr>
<tr>
<td>AS</td>
<td>24.028 ± 0.271</td>
</tr>
<tr>
<td>CR</td>
<td>22.572 ± 0.348</td>
</tr>
<tr>
<td>CS</td>
<td>27.265 ± 0.339</td>
</tr>
</tbody>
</table>

Values are means ± SE. GSD, Gregorc Style Delineator; MDSC, Medical Science; AR, abstract random; AS, abstract sequential; CR, concrete random; CS, concrete sequential.

The GSD results were modified accordingly to obtain numerical range values for the variables Sequential vs. Random, which were divided into three levels of usage. The new variable of sequential [S] was produced by adding the values of CS and AS together. The new variable of random [R] was produced by adding the values of CR and AR together. The resultant variables, [S] and [R], are linearly related on a single unidimensional bipolar scale. This relationship can be described mathematically as [S] + [R] = 100. Thus, knowing the value of one of these two variables yields the value of the other. Therefore information on one variable automatically provides information on the other. Hence, a single ANOVA on the [S] variable (see Table 4) was used to determine its relationship to MDSC 200 achievement.

The [S] variable was divided into intervals on the basis of Gregorc’s breakdown of usage levels of the learning styles into dominant, intermediate, and low levels. Gregorc (1) defined dominant styles to have 27–40 points, intermediate styles to have 16–26 points, and low styles to be of 0–15 points. To break up the [S] variable into similar intervals of dominant, intermediate, and low it was necessary to double the values used in the ranges defined by Gregorc. This resulted in intervals consisting of dominant (54–80), intermediate (32–52), and low (20–30). The formation of the new [S] variable from the data obtained from the GSD scores of the nursing students in MDSC 200 produced values ranging from 29 to 69. The lack of values in the low range of the [S] variable led to a modification of the ranges used to form the three new usage intervals: dominant (54–80), intermediate (41–53), and low (0–40), which transferred part of the range assigned...
**TABLE 3**
Sequential ability and corresponding final course scores

<table>
<thead>
<tr>
<th>Sequential Ability Interval</th>
<th>( n )</th>
<th>Mean Sequential Ability</th>
<th>Mean Final Course Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (0–40)</td>
<td>31</td>
<td>36.87 ± 0.538</td>
<td>63.75 ± 1.923</td>
</tr>
<tr>
<td>Intermediate (41–53)</td>
<td>117</td>
<td>47.78 ± 0.335</td>
<td>64.44 ± 0.969</td>
</tr>
<tr>
<td>Dominant (54–80)</td>
<td>112</td>
<td>59.22 ± 0.338</td>
<td>65.19 ± 1.064</td>
</tr>
</tbody>
</table>

Values for mean sequential ability and mean final course score are means ± SE.

from the lower end of the intermediate interval to the low interval. Table 3 provides the mean scores for sequential ability and corresponding mean (± SE) final course scores for the three intervals of sequential ability usage. The ANOVA results indicated that the three levels of sequential ability usage (Table 4) are not related to overall final course scores.

**DISCUSSION**

The main objective of this study was to determine whether the GSD could be used to predict achievement in a human anatomy and physiology course. A positive association between learning styles and achievement would assist instructors of anatomy and physiology in developing more effective lessons that could enhance student performance. Results in Table 1 indicate that the dominant learning styles employed by the nursing students who completed the GSD are CS and AR, which is in agreement with Wells and Higgs (7).

Factor analysis of the GSD and examination scores produced unexpected results. This analysis demonstrated that there is no relationship between examination scores and learning styles allegedly identified by the GSD. The most significant finding obtained from the factor analysis was that the GSD data collapsed from two bipolar scales into a single bipolar scale. For example, factor two in Table 2 shows that perceptual ability (Abstract vs. Concrete) does not exist as a separate factor but instead is part of the unidimensional variable of ordering ability. These results clearly demonstrate that Gregorc's assumption regarding the alleged existence of four distinct learning styles, comprised of two bipolar scales, is incorrect. In other words, the perceptual ability (Abstract vs. Concrete) used by Gregorc does not provide any additional information about the learner than that already provided by ordering ability (Sequential vs. Random). Another finding by ANOVA was that the degree of sequential ability usage was not related to achievement as measured by final course scores. Although the results of the present study bring into question the validity of the GSD, other reports (4) have also questioned its reliability as a suitable instrument for identifying and evaluating learning styles.

In conclusion, this study found that the dominant learning styles for nursing students in MDSC 200, identified by the GSD, were CS and AR. More importantly, this study found no relationship between GSD learning styles and achievement in MDSC 200. In addition, this study demonstrated that Gregorc's assumption regarding the existence of four distinct learning styles is not supported by the GSD data. These results clearly indicate that the GSD cannot be used to help predict student achievement on examinations in an introductory anatomy and physiology course. The main recommendation from this study is that, because the GSD does not measure what it purports to measure (and thus lacks validity), future use of the GSD is not encouraged.

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