Learning Styles Among Undergraduate ‘Science for All’ Student Scholars
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Abstract
Researchers have been interested in assessing college-aged students’ learning styles for several decades. However, little is known about the learning styles of students who may be destined for careers in the sciences. The purpose of this study has been to describe the learning styles types of undergraduate science scholars. The findings of 151 students showed that Type 4 (n= 39, 26%) and Type 3 (n= 37, 24%) learners were more frequent than Type 1 (n= 30, 20%), Type 2 (n=25, 17%), and a combination of two or more learning styles (n= 20, 13%). Students also showed more than a two to one preference for left-brain modes (n= 102, 68%) compared to right brain modes (n=49, 32%). Identifying the learning styles of an entire class provides instructors with an opportunity to create more effective instructional designs and provides students with new perspectives about their learning potential.

Keywords: effective learning, experiential learning, learning styles, perception, reflection

Undergraduate Learning Styles
Research on learning styles among college-aged students has been a topic of interest to investigators for decades (Blank, & James, 1993; Conti, Welborn, 1986; Felder & Silverman 1988; Orr, Park, Thompson, & Thompson, 1999; Petty & Holtzman, 1991; Rochford, 2006; Scribner, & Anderson, 2005; Thompson, Orr, Thompson, & Park, 2002). However, little research has been reported on the learning styles of college-aged students who may be destined for roles in sciences, engineering, and medicine. Individuals have unique perceiving and processing skills that influence how they take in new information and what they do with it. Each individual has his/her own unique style, preferences for the ways in which they learn best, and ways in which learning is challenged. These preferences for perceiving and processing are referred to as learning styles. Learning styles
are believed to be pre-disposed and biological, however, researchers have observed that when students' learning preferences are matched with complementary instruction, improved academic achievement results (Dunn & Dunn, 1993, 1999; Lovelace, 2005).

**Measuring Learning Styles**

Researchers estimate that there are more than 70 models of learning (Alfonseea, Carro, Martin, Ortigosa, & Paredes, 2006; Brown & Brailsford, 2005; Coffield, Moseley, Hall, & Ecclestone, 2004b; Johnson, 2007). Learning style surveys are typically used to classify students along continua or dimensions. Some surveys such as the VARK (Fleming, 2001) assesses students' preferences for visual, auditory, reading, and kinesthetic, others such as the Paragon Learning Styles Inventory measures cognitive preferences for extra-introversion, intuitive-sensory, thinking-feeling, or judging-perceiving, (Shindler & Yang, 2003), while others such as the Index of Learning Styles (ILS) by Felder and Silverman (1988) classify students across four dimensions of learning including active, visual, sequential and sensory.

Although there are many learning styles assessment tools, some researchers argue that there is little supporting evidence for learning styles (Coffield, Moseley, Hall, & Ecclestone, 2004a, c). Among the cited criticisms of learning style assessment tools are the lack of a consensus theory, consistent psychometric failings, disregard for the use of effect size, a lack of reported research about positive effects related to application and practice, and incestuous research practiced in a field of self-affirming replication. Others have written that learning style are an elixir, a dangerous chimera and fool's gold marketed by insincere trainers only interested in the sale of the related tools (Rayner, 2006). In the United Kingdom, the notion of learning styles has been a dominant theme in professional discourse during the last decade (Coffield, Moseley, Hall, & Ecclestone, 2004c; Rayner, 2007). Despite these criticisms, Rayner (2007) points out that:

The construct of style continues to carry an exceptionally high value in terms of ‘face validity’ (Witkin, 1962; Messick, 1976; Rayner, 2001). Teachers repeatedly say how they work with individual differences and that this does in fact reflect a person's style of working and learning (Rayner, 2007: 26).

Using case examples, Rayner (2007) explains how a student who came to know his personal learning style was able to develop a more positive self-perception as a learner. He asserts that the assessment of learning styles can be a beneficial tool in the analysis of a student's functioning and performance yet it is often neglected. Assessing learning styles can be an intervention tool in contrast to those that focus ex-
clusively on skills practice and knowledge acquisition. Rayner (2007) argues that style-led testing has implications for wide formative assessment; it provides more personalized information about students, that which is beyond achievement measures of performance. Research with undergraduates showed that a workshop on understanding personal learning styles was worthwhile (Hendry et al., 2005).

Learning styles holds promise for program development and formative curriculum assessment because it helps teachers appreciate the importance of providing instruction in thinking skills, encourages teachers to use a wide range of instructional strategies and shows respect for students’ individualities and differences as learners (Rayner, 2007). For example, Dunn (1990) reported the benefits of instructors accommodating students’ learning styles. She found that it could boost student performance by nearly one standard deviation (Cited in Davis & Franklin, 2003). In a study that focused on performance differences between students who learned better individually or via group instruction, Felder and Silverman (1988) observed that extroverted introductory engineering students earned almost one full letter grade higher than introverts (Cited in Davis & Franklin).

Gelso and Lent (2000) have argued effective scientists utilize logic and skepticism while exploring information. Also, they have theorized that personal factors, such as learning styles are important for instructors to assess so that they might determine how to select students for graduate research training. Moreover, West, Kahn and Nauta (2007) found that three of four dimensions of learning styles using the Index of Learning Styles (ILS) were predictive of research interest or research self-efficacy. These findings show the relevance of learning styles in assessing personal factors to determine which students might be destined for engagement in research.

In this study, a descriptive analysis of the learning styles among undergraduate science scholars enrolled in a course entitled Science for All, at a Research I intensive university located in the Southeast is reported. This course was of interest to the researchers because it served as a gatekeeper for students who wanted to apply for a prestigious fellowship to work under the tutelage of research professors in the sciences, engineering and medicine. During the 16-week course experience, students were presented with an overview of some of the research studies that were being conducted on the college campus. Nearly 45 professors presented a brief presentation of their research programs including faculty members from chemistry, biochemistry, biomedical engineering, cancer genetics, pathology/stem cell biology, neuroscience, and ophthalmology, genetics and gynecology. In this
study, researchers asked the question: What are the learning styles among the Science for All students?

Methods

Students enrolled in the Science for All course during the Fall 2006 (n = 124), Spring 2007 (n = 95), and Fall 2007 (n = 144) sections were invited to participate. During the first four weeks of class, one of the authors made an announcement to the students about the purpose of the study and invited them to participate. She told the students that by taking the Learning Type Measure (LTM) and Hemispheric Mode Indicator (HMI) that they could discover their learning preferences and infer which style of teaching they most preferred and least preferred. Students received information about the link to the online site where they take the surveys. In return for their participation, they received a summary from aboutlearning.com that explained their learning styles types at the conclusion of their session.

The LTM and HMI were used in this study because they offer test-takers practical and easily understandable interpretations of the self in situational circumstances. The LTM is a ‘. . . 26-point self report questionnaire measures individual preferences for selecting, organizing, prioritizing and representing knowledge, information and experience’ (About Learning, 2008) www.aboutlearningdata.com/sim2.asp). The hemispheric dimension of the LTM presents another preference indicator for approaching and representing content and concepts. The theoretical constructs of the LTM and HMI are grounded in the work of Bogen (1969, 1975), Jung (1976), Kolb (1974, 1984), Lewin (1951), Myers (1962), and McCarthy (1980, 1987, 1996, 2000).

Data was maintained at a server at aboutlearning.com and was retrieved by the first author following the semester in which the data was collected. Data was collected at three time points, Fall 2006 (n = 89 of 124 students, or 72%), Spring 2007 (n = 28 out of 95 enrolled students, or 29%), and Fall 2007 (n = 34 out of 144 enrolled students, or 24%). A total of 363 students were enrolled in the Science for All courses during the time of this study. A total of 151 students, 42% of the population, took the LTM and HMI. However, students were permitted to take the Science for All course up to three times. The researchers controlled for the possibility of students taking the LTM and HMI more than once by reviewing the personal identity codes maintained by aboutleaning.com. A careful review of the three datasets indicated that none of the participants took the surveys more than once.

The Learning Type Measure (LTM)

The learning type measure consists of two parts. Part A contains 15
items, each with four stems. Respondents were asked to rank order the stems from 1 (least like you) to 4 (most like you). Each of the stems represents one of the four learning styles. Part B consists of 12 items with two choices each. Respondents are asked to select one of the two choices that are most nearly like themselves. Each of the stems represents a “Doer” or “Watcher.”

Reliability of the LTM. Two forms of reliability are reported, Cronbach’s alpha, a measure of internal consistency and test-retest reliability, a measure of stability. While alpha of greater than .80 is generally necessary for achievement, in attitude or affective measures, an alpha of equal to or greater than .70, is sufficient to assert that there is internal consistency. Cronbach’s alpha for Part A and Part B of the LTM is shown in Table 1.

Table 1. Internal Consistency for the LTM Item Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A:</td>
<td></td>
</tr>
<tr>
<td>Learning Type One</td>
<td>0.853</td>
</tr>
<tr>
<td>Learning Type Two</td>
<td>0.835</td>
</tr>
<tr>
<td>Learning Type Three</td>
<td>0.767</td>
</tr>
<tr>
<td>Learning Type Four</td>
<td>0.883</td>
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<tr>
<td>Part B:</td>
<td></td>
</tr>
<tr>
<td>Do vs. Watch</td>
<td>0.883</td>
</tr>
</tbody>
</table>

The test-retest reliability coefficient is indicative of the measure’s consistency over time; it is also called the coefficient of stability. Analysis of the LTM scores yielded .71, the test-retest coefficient of stability.

Validity of the LTM. The stems in the 15 items of Part A are indicative of one of the four learning styles types (About Learning Incorporated, 2000). To determine if the LTM has construct validity, 390 individuals took the inventory and a frequency distribution of the scores was created. Of the participants, only 2.6% (n = 10) had no single type, 42.8% (n = 167) were type ones, 14.1% (n = 55) were type twos, 20.0% (n = 78) were type threes, and 20.5% (n = 80) were type fours.

To establish concurrent validity, scores from the LTM were compared with the Learning Style Inventory (LSI) and the Myers Briggs Type Indicator (MBTI) (About Learning Incorporated, 2000). Individuals (n=175) took both the LTM and LSI. The researchers tested the relationship between the LTM and LSI using a contingency table analysis and determined the strength of the relationships using the chi-square
test, Cramer's V and Contingency Coefficient. All three showed a significant relationship between the LTM and LSI. There was 61% agreement between both measures. Chi-square statistic =137.423 was significant at p< .0001. An overview of the significant relationships between the Myers Briggs and the LTM follow. The Feeling score (F) is most associated with the Learning Type 1 score. The Introvert (I), Thinking (T), and Judging (J) were most associated with the Learning Type 2 score. The Sensing (S) score was most associated with the Learning Type 3 score. The Extrovert (E), Intuitive (I), and Perceiving (P) scores were most associated with the Learning Type 4 score.

Results

Learning Type Measure (LTM)

The results of the Learning Style Types by semester are shown in Figure 1. The LTM for Fall 2006 students was Type 1 (n=10, 11%), Type 2 (n= 24, 27%), Type 3 (n= 28, 31%), Type 4 (n= 14, 16%), a combination of two or more learning styles (n= 13, 15%). The LTM for students in the Spring 2007 class were Type 1 (n=10, 36%), Type 2 (n= 0), Type 3 (n= 8, 11%), Type 4 (n= 11, 39%), a combination of two or more learning styles (n= 3, 9%). The Learning Type 5 for students in the Fall 2007 class were Type 1 (n=10, 29%), Type 2 (n= 1, 3%), Type 3 (n= 6, 18%), Type 4 (n= 14, 41%), a combination of two or more learning styles (n= 3, 9%). The combined Learning Style Types for all three semesters are shown in Figure 2 where Type 4 (n= 39, 26%) followed by Type 3 (n= 37, 24%), Type 1 (n= 30, 20%), Type 2 (n=25, 17%), and a combination of two or more learning styles (n= 20, 13%). Overall, the combined LTM results showed that Types 4 and 3 were most frequent.

Figure 1. Learning Style Types for Science for All Students by Semester
Figure 2. Combined Learning Style Types for All Science for All Students (n=151)

**Hemispheric Mode Indicator (HMI)**

The results of the Hemispheric Mode Indicator by semester are shown in Figure 3. Students in Fall 2006 were mostly left brained (n=53, 60%) compared to right brained (n=36, 40%). Spring 2007 students were mostly left brained (n=25, 59%) compared to right brained (n=3, 11%), and Fall 2007 students were also mostly left brained (n=24, 71%) when compared to right brained (n=10, 29%). The combined results for all three semesters of the Hemispheric Mode Indicator shown in Figure 4 indicate that the left-brain mode (n = 102, 68%) students were more frequent than the right brain mode (n = 49, 32%) students by more than a two to one margin.

**Discussion**

Overall, the results showed that of the participants, most of the students were Type 4 (n= 39, 26%) learners followed by Type 3 (n= 37, 24%), Type 1 (n= 30, 20%), Type 2 (n=25, 17%), and a combination of two or more learning styles (n= 20, 13%). Type 4 and 3 learners accounted for half of the sample. Students also showed more than a two to one preference for left-brain modes (n= 102, 68%) compared to right brain modes (n=49, 32%).

Knowing students' learning styles and hemispheric mode indicators has implications for teaching. For example, Type 4 learners perceive
information through direct experience and process it actively. They seek challenges and ask themselves: What are the possibilities for using this newly acquired information? They learn primarily by self-discovery. In personal interactions, they deal with conflict by reacting emotionally and then move on to rationality. In teaching Type 4 learners, instructors need to let students teach the information to themselves and then to others. The more these students experience the information on their terms, the better they become with processing and integrating it. In relationship to the HMI, Type 4 learners perceive by feeling and process by doing.

Figure 3. Hemispheric Mode Indicator for Science for All Students by Semester

![Figure 3. Hemispheric Mode Indicator for Science for All Students by Semester](image)

Figure 4. Combined Hemispheric Mode Indicator for All Science for All Students (n=151)

![Figure 4. Combined Hemispheric Mode Indicator for All Science for All Students (n=151)](image)

Type 3 learners perceive information abstractly and process it actively. These learner types excel at problem solving and learn best with hands-on experience. They are pragmatic, competent and oriented towards getting things done. They deal with conflict by creating
solutions. They learn best when instructors let them experiment or try the information or technique. In relationship to the HMI, Type 3 learners perceive with thinking and process by doing, acting on or with the new information and making sense of it.

Type 1 learners, who represented a fifth of the sample, learn by experience and through perception. They reflect upon their experiences as they seek meaning. They learn primarily through dialogue, listening and sharing ideas. In personal interactions, they build trust and seek harmony. Instructors need to give them a reason for learning. Teaching to these students' preferred modes of perceiving and processing will strengthen their preferences and is likely to result in higher outcomes than if they were taught to their least preferred modes. In relationship to the HMI, Type 1 learners perceive with feeling and process by watching, subjectively introspecting before using the information or experience.

Type 2 learners perceive information abstractly and process it through reflection. They integrate observations with prior knowledge and formulate concepts and theories that help them integrate newly acquired information with knowledge that they already possess. They excel in traditional learning environments that are characterized by lectures and reading. They process new information systematically, logically, and analytically. In interactions with others, they build trust byknowing and presenting facts. They excel in learning environments in which the instructor just gives them the facts. In relationship to the HMI, Type 2 learners perceive with thinking and process by watching.

Students who showed preference for two or more learning styles are able to operate in more than one channel. Because their learning preferences are varied, this increases their ability to relate to different forms of instruction and classroom environments (Thompson, Orr, Thompson & Park, 2002).

Left-brain mode students are logical and rational. They learn new information sequentially and verbally. They work to analyze and break down information. The left mode learner prefers instruction that is grounded in objective, rational, systematic and literal representations. Right-brain mode students are intuitive and emotional. They learn new information holistically. They learn best through hands-on experiences. They work to synthesize and consolidate new information. The right mode learner has a preference for instruction that is based on subjective, intuitive, synergistic and figural representations.

The major premise that underlies learning types and hemispheric-
ity is that when students know their learning styles and hemispheric preference, then they have a better sense of how they learn best and under what conditions they learn best. Learning styles influence the ways that students learn. For example, learning styles may make the same teaching method effective for some students and ineffective for others. Thus, knowing individual strengths and weaknesses can help students adapt their study habits to maximize his/her learning outcomes especially in courses where teaching does not match their preferences or challenges their styles. While learning styles offer formative assessment, it is important to point out the application of learning styles is a tool, not a way of reducing students to a category or label (Rayner, 2007) and as such is not a substitute for knowledge.

To enhance instructors’ awareness of learning styles in general first, they must identify their own learning styles and those of their students. For example, instructors could analyze the impact of their learning styles on the instructional methods they select by videotaping themselves during teaching (Scribner & Anderson, 2005). Instructors might also observe instructors with different learning styles and see the effect of their styles on teaching. Team teaching with others who have different learning styles can also enhance students’ exposure to varied learning styles and help instructors learn how to vary their own ways of teaching (Orr, Park, Thompson & Thompson, 1999). Pairing students with different learning styles will create synergy, allow students to observe how others learn, increase their tolerance for others’ learning styles and help them learn how to think and react during different problem-solving situations. Beyond the benefits for students, instructors will have an opportunity to learn how the synergy affects student learning and to reflect upon how their own learning styles can facilitate or inhibit student outcomes (Orr, Park, Thompson & Thompson, 1999).

As Thompson, Orr, Thompson, and Park (2002) have suggested, instructors must be proactive in meeting students learning needs. They recommend that instructors administer Brookfield’s (1990) Critical Incident Questionnaire halfway during the semester to allow students to report if their learning needs are being met. This information can provide instructors with formative feedback that would allow them to revisit and/or modify learning activities to accommodate students with varied learning styles. In this study, lecture presentations were the predominant instructional modality used in their course; no hands-on or laboratory assignments were utilized. Thus, the course director might consider how varying instructional delivery might influence students with varied learning styles to consider a career in science and what role this course could play in that process.
Knowing students preferred modes helps instructors tailor instruction to students’ preferences and build strength in areas where they have less dexterity. Having information about students’ learning preferences can help instructors realize the imperative to move away from teaching that is aligned with their own learning preferences. With this information, instructors may avert their predisposition to treat all students as if they were similar (Lugan & DiCarlo, 2006). While the learning styles measures suggest behavioral tendencies, they are infallible predictors of behavior (Felder & Spurlin, 2005). Recognizing that learning styles are influenced by educational experiences is also important. Students with a preference for kinesthetic activities who take a course that is information laden and delivered by lecture but augmented by guided activities that ensure conceptual understanding might realize increased strengths and preferences for verbal instruction while their strengths in kinesthetic processing and perceiving might lessen (Felder & Spurlin, 2005).

Learning styles assessments gives instructors who try ‘... to concretize and systematically apply knowledge about learning styles ...’ (Bostrom & Lassen, 2006: 182) a rationale for selecting particular instructional designs or individualizing instruction. Identifying the learning styles of an entire class provides a profile for instructors that offers additional support to work towards creating effective instructional designs (Felder & Spurlin, 2005). Creating student awareness of their learning styles influences meta-cognition and choice of relevant learning strategies (Bostrom & Lassen, 2006). For example, sharing the results of these measures with students offers valuable insight about their possible strengths and weaknesses. When this information is coupled with insight about things that they can work on to improve academic performance (Felder & Spurlin, 2005) they can acquire new perspectives about their learning potential (Bostrom & Lassen, 2006). Often when students consistently experience academic difficulties with particular courses or instructors, they tend to blame this on poor teaching and neglect to take ownership for their own failure (Felder & Spurlin, 2005). Reframing their own difficulties as a conflict between teaching styles and their own learning styles may represent an initial step in seeking assistance towards what they need in or outside of class. Thus, ‘becoming aware of one’s learning style gives an individual a basis for comprehending both the impact of internal and external stimuli’ (Bostrom & Lassen, 2006: 185). In this way, understanding learning style preferences can be empowering and transforming (Felder & Spurlin, 2005) and encourage and develop deeper motivation (Bostrom & Lassen, 2006).
Conclusion

Overall, the findings in this study showed that students have greater preference for Types 4 and 3 learning styles, closely followed by Type 1 styles and are primarily left-brain mode learners. Taken together, Types 4 and 3, and a combination of two or more learning style type students represented slightly less than one third of the sample. The sample population of science students did not show a clear and distinct preference for one learning style, while they did show a clear preference for the left mode. Since students received only lectures in the Science for All, in some way, instruction was tailored to their hemispheric mode preference for objective and literal representations. However, all four learning styles and as well as a combination of two or more learning styles were represented among the students in this sample who were enrolled in the Science for All course.

The implications of the findings are that perhaps not all types of learners are being attracted into fields of study in sciences, engineering, and medicine. The findings also suggest that instructors can use this information to more carefully tailor instruction to meet the learning needs of all students, build upon their existing strengths, and develop additional competencies in their less preferred modes (Bostrom & Lassen, 2006). The need for more variety in learning experiences and activities to complement students’ preferences and strengthen their least preferred learning styles is supported by the use of only lectures during the course. Since students did not have opportunities to experiment with the information, engage in hands-on learning activities, teach the material to themselves and others, or to dialogue and share ideas with one another student, they were not necessarily experiencing teaching that complemented their preferred styles. The findings showed that there was enough variety in students’ learning styles that point to the importance of accommodating and encouraging students with different learning styles (Orr, Park, Thompson & Thompson, 1999). Perhaps more important, is the recognition that learning styles represent a key to understanding thinking processes, as well as a means to monitor learning and use students’ perceiving and processing strengths (Bostrom & Lassen, 2006).

Notes
1. Science for All is a pseudonym.
2. This research was made possible by an award from the Howard Hughes Medical Institute (Award # 00062786). The contents of the paper are the solely the reflection the authors' work, not the agency.

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