

# An Examination of the Relationship between Instructional Strategies to Learning Styles Distance and Students' Achievements\*

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Some researchers claim that a close match between a student's learning style (LS) and the teacher's instructional strategies (IS) supports students' achievements. Accordingly, in order to maximize student achievements, teachers should adjust their teaching strategies to fit their students' learning styles. The current paper deals with a true field experiment aimed at examining the relationships between the distance of teachers' IS to students' LS and students' learning achievements. An IS-LS distance for each student and his or her teacher was measured, and its correlation to this student's achievements was calculated. The Felder-Soloman Index of Learning Styles (ILS) was used to measure students' preferred LS as well as teachers' preferred IS and a method for measuring the IS-LS distance was developed. The research population, comprising 165 students and 8 teachers from one high school and two colleges, completed the ILS questionnaire. The absolute value of the difference between the student's LS to teacher's IS defined the IS-LS distance; the distances were calculated for each student and the relevant teacher. If the argument that a good IS-LS match contributes to a student's achievement is valid, then a significant negative correlation between the IS-LS distance and the student's achievements must appear. The correlations between the IS and LS distances and students' achievements in 17 courses were calculated in order to answer the above question. The research findings do not support the assumption that matching IS to LS improves student achievements.

**Keywords:** engineering education; instructional strategies; learning styles

## 1. Introduction

Felder and Silverman [1, 2] claim that student learning is determined by the student's ability, the student's background and the match between the student's learning style (LS) and the teacher's instructional strategies (IS). Mismatches exist between conventional learning styles of engineering students and traditional teaching styles of engineering professors. Consequently, students often become bored and inattentive in class, do poorly on tests, get discouraged about courses, the curriculum, and themselves, and in some cases, switch to other curricula or drop out of school. Felder and Silverman conclude that teachers can do nothing about students' given characteristics such as ability, background and LS. Therefore, in order to maximize students' achievement, teachers should adjust their IS to fit students' LS. Waks [3] takes into consideration the match between LS and IS as part of his model for curriculum design. He raises numerous questions concerning the IS-LS match. The issue of whether a good match indeed improves the learning process is the subject of the research described in the current paper.

In earlier studies by the authors [4, 5], a method for measuring the match between each IS dimension

to each corresponding LS dimension, as well as for measuring the match between the overall IS and the overall LS, was developed. The correlation between these variables and students' achievements were calculated in order to verify whether the match of IS to LS influences students' achievements. The results of both studies did not support the assertion that a close IS-LS match contributes to improved student achievement. The research in [4, 5] used the Five Dimensions Questionnaire [1, 2]. The authors decided to reexamine the findings of the earlier research using Felder and Soloman's newer Learning Styles Questionnaire [6] and a new population. The current paper presents the results of this new research. The previous studies [4, 5], in the same way as the current one, did not create a research setting in which the teachers teach according to their students' LS. Rather, the investigation was carried out in regular classes, with the teachers teaching using their usual pedagogical methods and the correlative approach measured the correlations between students' grades and the match of teachers' IS to students' LS.

The paper is organized as follows: Section 2 provides a theoretical review of models of learning styles followed by the Felder-Soloman Index of Learning Styles (ILS) and its validity and reliability;

the pros and cons regarding matching *IS-LS*; the need for diversification of teaching methods and a discussion of the aspects of constructivism in the literature that could explain the students' achievements better. Section 3 presents the research question, the research method and the research setting. In Section 4, the findings are described. In Sections 5 and 6, the findings are further discussed, conclusions presented and future research directions suggested.

## 2. Literature review

### 2.1 Models of learning styles

The idea that different students have different *LS* has been known and investigated for a long time. According to Guild and Garger, the first teacher/philosopher who used the term style was Hippocrates (460–370 BCE) [7]. The use of *LS* in education is rooted in psychological theories such as Jung's four psychological functions by which humans experience the world—sensation, intuition, feeling, and thinking [8]. According Zhang, abilities refer to what one can do whereas styles refer to how one prefers to use one's abilities. He argues that students having a high level of cognitive development tend to use a wider repertoire of thinking styles [9].

There are several *LS* models. The cognitive styles theory associated with Sternberg offers four forms of mental self-government: hierarchical, monarchic, oligarchic, and anarchic [10]. Lemire suggests the five learning styles model [11], and argues [12] that Gardner's multiple intelligences [13] are simply *LS*. The Myers-Briggs Type Indicator (MBTI) is based on Jung's Psychological Types: extroverts (try things out, focus on the outer world of people) or introverts (think things through, focus on the inner world of ideas); sensors (practical, detail-oriented, focus on facts and procedures) or intuitors (imaginative, concept-oriented, focus on meanings and possibilities); thinkers (skeptical, tend to make decisions based on logic and rules) or feelers (appreciative, tend to make decisions based on personal and humanistic considerations); judgers (set and follow agendas, seek closure even with incomplete data) or perceivers (adapt to changing circumstances, resist closure to obtain more data) [14]. Kolb and Boyatzis present four types of learners: active–reflective processors and concrete–abstract perceivers [15].

### 2.2 The Felder–Silverman index of learning styles (ILS)

Felder and Silverman's work about learning and teaching styles in engineering education [1] is probably the most well-known one in this field. Never-

theless, Felder and Silverman, with appropriate modesty, note that their *LS* dimensions are “neither original nor comprehensive” [1, p. 675]. They define five *LS* dimensions: perception (sensory or intuitive), input (visual or auditory), organization (inductive or deductive), processing (active or reflective) and understanding (sequential or global). Their corresponding *IS* dimensions are: content (concrete or abstract), presentation (visual or verbal), organization (inductive or deductive), involving the learner (active or reflective) and perspective (sequential or global). These *LS* and *IS* are relevant to engineering and technology education [1, 3].

Felder and Silverman show how to measure the Preferred Learning Style. For example, the two ends of the scale for the perception dimension are sensing and intuitive. Each direction has three levels (mild, moderate, or strong) as shown below. The student is asked to mark his or her preferred style on this scale [1].

Sensing     |     |     |     |     |     |     Intuitive  
                  Strong   Moderate   Mild   Mild   Moderate   Strong

In [16], Felder explains the reasons for changing the model by dropping the inductive/deductive dimension, and changing the visual/auditory category to visual/verbal so that it becomes the four dimensions model. The web version of the latter Index of Learning Styles Questionnaire is a convenient tool for measuring one's preferred *LS*. It consists of 44 statements, 11 for each dimension. The respondent can choose ‘a’ or ‘b’, depending on how much each reflects his or her preference for each statement. For example, for the statement “I understand something after I”. . . , an active learner would mark ‘a’—try it out and a reflective learner would mark ‘b’—think it through [6]. Every ‘a’ response counts as +1 whereas the ‘b’ response counts as –1; this scoring method dictates the range of –11 to +11 for each dimension [17–19].

Many researchers relate to the validity and reliability of the Felder–Soloman Index of Learning Styles [17, 18, 20–22]. Zywno uses 557 questionnaires for her Cronbach's alpha analysis that resulted in Cronbach's alphas between 0.53 and 0.70 for the four *LS* dimensions, whereas alpha > 0.5 is acceptable for attitude assessment. She also points out that three of the four dimensions are orthogonal and there is a small correlation between the sensing/intuitive and the sequential/global dimensions [20].

### 2.3 The *IS-LS* match and students' achievements

Gilakjani argues that teachers should make every effort to match their *IS* to their students' *LS*. He also

claims that matching *IS* to *LS* could produce statistically significant improvements in the students' grades [23]. Hawk and Shah believe that familiarization with learning style models can potentially enhance the learning. These researchers, however, do not present empirical evidence for their assumption. They also believe that most faculty in higher education institutions adopt the teaching style they would prefer their teachers to use if they were the students and prefer approaches to teaching they felt were effective for their own learning [24]. Tulbure conducted a wide literature review including several sources that support the idea that matching *IS* to *LS* contributes to students' achievements. Other researchers oppose the idea of matching while still others reach no categorical conclusion. Tulbure [25] as well as [26] suggest that further research should be carried out. Many researchers suggest ways for matching teaching to *LS* [27–30]. Carver et al. recommend using multimedia in order to meet students' *LS* [28]. Hanselman argues that teaching the continuous-time concept before discrete-time in analog and digital signals and systems subjects in electronics should be preferred since it supports the inductive progression of learning, addresses the needs of sensing students and helps the global and sequential learners. He, nevertheless, does not present empirical evidence that such a curriculum design contributes to students' achievements [27].

#### *2.4 Doubts concerning the IS–LS match and students' achievements approach*

Lemire describes three serious problems associated with *LS*: confusion in definitions, weaknesses in reliability and validity, and the identification of relevant characteristics in the instructional setting. He also argues that professionals should be skeptical of claims made by many researchers in the area of *LS* concerning validity and reliability [12]. Delahoussaye gathered seven experts (Kolb, Honey, Curry, Salton, Fields, Daly, and O'Brien) for a debate on *LS*. The participants believe that there is merit in using *LS* for training. Honey argues that preferences are more subjective and harder to measure accurately than manifest behaviors. Salton answers “yes” to the question: Is there evidence to validate the practical relationship between *LS* and learning effectiveness? He, however, adds that this does not mean anything in practice. In the real world, training occurs in a group context. Kolb, referring to the question “should we teach exclusively to an individual's preferred style?”, says that this is a bad idea. He prefers designing a curriculum so that every type of learner is allowed to create a specific or particular linkage with the material [31]. Felder and Spurlin argue that learning style preferences are not reliable

predictors of learning strengths and weaknesses [17]. Zywno presents a case of 124 students who answered the same *ILS* questionnaire twice in a period of eight months (once at the beginning and again at the end). The correlation between the two measures is 0.7. In her opinion, the results indicate stable *LS*; nevertheless, she calls for further research on this issue [20]. The authors of the current paper do not agree that a correlation of 0.7 after eight months indicates stable *LS* and prefer Felder's assertion that students' *LS* may change over time, and may vary from one subject or learning environment to another [17, 27]. Wilson studied the issue of matching *IS* to *LS* and concluded that significant questions remain about the matching effectiveness [33]. Pashler, McDaniel, Rohrer, and Bjork argue that the contrast between the enormous popularity of the *LS* approach within education and the lack of credible evidence for its utility is striking and disturbing [34]. The reservations touched on briefly above are in line with the conclusions presented in the current authors' previous papers [4, 5].

#### *2.5 A better idea—diversifying instructional strategies*

In [30, p. 3] Felder argues, “the point is not to match teaching style to learning style but rather to achieve balance, making sure that each style preference is addressed to a reasonable extent during instruction.” In [32], Felder explains that it is better for every student to be able to function with all learning styles modes. He suggests, therefore, that “if professors teach exclusively in a manner that favors their students' less preferred learning style modes, the students' discomfort level may be great enough to interfere with their learning. On the other hand, if professors teach exclusively in their students' preferred modes, the students may not develop the mental dexterity they need to reach their potential for achievement in school and as professionals” [32, p.18]. Felder and Soloman suggest various methods for how students can help themselves adapt to their teachers' different styles [36]. This latter approach is in line with constructivism theory, which states that the learner is the one who processes the acquired knowledge in his or her mind and adapts it to the existing conceptual system and the purpose at hand [37, 38].

The paper presented here deals with a true field experiment in which an *IS–LS distance* for each student and his or her teacher was measured, and its correlation to this student's achievements was calculated. This approach differs from that reported in the literature above, where statistical tools deduced the relationship between *IS–LS distance* and students' achievements in large groups. Additionally, the literature above raises some doubts about relia-

bility, validity, stability and the *LS* ability to predict learning success. The authors of the current paper report about a new measuring approach and its results, adding to the knowledge about *IS* and *LS* and supporting the argument that good teaching needs the use of various teaching methods rather than a focus on the *IS–LS* match.

### 3. Methodology

#### 3.1 Research question and hypothesis

The current paper seeks to resolve the following: Does a close match between *IS* and *LS* improve a student's learning achievements? It sounds reasonable to believe that if a close *IS–LS* match indeed has a positive affect on the student's achievements, then a significant negative correlation between the *IS–LS distance* and the student's achievements must emerge. The formal definition and the method of measuring the *IS–LS distance* is given at the end of Section 3.3.

#### 3.2 Research population

The research population comprised 165 students and eight teachers: 47 students in grades 10, 11 (one group each) and grade 12 (two groups) and their two teachers from high school; 29 students from college 1 (second year) and their four teachers, 89 students from college 2 (one group in first year and two groups in second year) and their two teachers. The college students were studying for a practical engineering degree (that is, a degree higher than a technician and lower than an engineer). All the students studied electronics. The teachers had been teaching between 6 to 35 years. Three of the teachers have a PhD, two have an MSc and three have a BSc. The data concerning the research population is summarized in Table 1.

#### 3.3 The learning styles questionnaire

For measuring *IS–LS distance*, the *ILS*—Index of Learning Styles Questionnaire [6] was translated into Hebrew and validated using four different groups of 20–30 students. Groups answered the questionnaire successively. All the comments given by the first group were discussed and then incorporated into the questionnaire. Thereafter, the second group filled in the questionnaire. This procedure was followed until the fourth group had no comments about the questionnaire. We note that these four groups are not part of the research population. Internal consistency was checked by calculating Cronbach's alpha for each dimension. The results, shown in Table 2—which presents values of Cronbach's alpha for the research population—are in line with the literature [17, 20]. Tuckman suggests that an alpha of 0.50 or greater is acceptable for questionnaires that assess attitude and preference [39]. The alpha values for all four dimensions of the *ILS* meet this criterion. Therefore, the internal consistency of the questionnaire is satisfied.

According to [24], teachers teach the way they preferred to learn when they were students. For this reason, the same questionnaire was used both for students and for teachers. The teachers were asked to answer the questionnaire as an instructional strategies questionnaire, e.g., item (4) in the *ILS* is “I tend to:”

- Understand details of a subject but may be fuzzy about its overall structure.
- Understand the overall structure but may be fuzzy about the details.

For teachers, the item considered as “I tend to” was either:

- Explain details of a subject but may be fuzzy about its overall structure. or

**Table 1.** The research population

School	Teacher no.	Grade	Course	Number of students
High school	Teacher 1	10	Digital systems	12
		11	Programming	10
		12, Group 2	Programming	16
		12, Group 1	Micro-controllers	9
	Teacher 2	12, Group 1	Analog electronics 1	
			Analog electronics 2	
Practical Engineering College 1	Teacher 3	Second year	Instrumentation 1	29
			Instrumentation 2	
	Teacher 4		Control	
	Teacher 5		Analog electronics	
	Teacher 6		Micro-controllers	
Practical Engineering College 2	Teacher 7	Second year, Group 1	VHDL	26
	Teacher 7	Second year, Group 2	VHDL	12
			Programming	
	Teacher 8	First year, Group 1	Analog electronics	14
		First year, Group 2	Analog electronics	26
		First year, Group 3	Analog electronics	11

- (b) Explain the overall structure but may be fuzzy about the details.

Based on [18, 19], Table 3 describes the items in the questionnaire associated with  $LS$  dimensions.

The score of dimension  $k$  for student  $i$  would be written  $LS_{ik}$ , where  $1 \leq k \leq 4$  and is calculated by summing all 'a' preferences and 'b' preferences that are associated with dimension  $k$ . Note that the total  $LS$  of student  $i$  as  $LS_i$  and it is calculated using Equation (1).

$$LS_i = \sum_{k=1}^4 LS_{ik}; \quad (1)$$

In other words,  $LS_i$  is the sum of the four dimensions' score for student  $i$ .  $IS_j$  is defined similarly for teacher  $j$ .

To define the  $IS$ - $LS$  distance, let  $LS_{ik}$  be the score given by student  $i$  for dimension  $k$ , and  $IS_{jk}$  the score given by teacher  $j$  for the corresponding dimension. The absolute difference  $D_{jik} = |IS_{jk} - LS_{ik}|$  is the distance between teacher  $j$  and student  $i$  for dimension  $k$ . The total distance between teacher  $j$ 's  $IS_j$  and student  $i$ 's  $LS_i$  is the sum of all distances of the four dimensions, calculated by Equation (2):

$$D_{ji} = \sum_{k=1}^4 |IS_{jk} - LS_{ik}|. \quad (2)$$

For example: the  $IS$  of teacher 2 for  $k1 = -7$  (Active-Reflective) and the  $LS$  of student 23,  $k1 = 1$ . Therefore,  $IS_{2,1} = -7$ ;  $LS_{23,1} = 1$  and the distance between teacher 2 and student 23 for  $k1$  is  $D_{2,23,1} = |-7 - 1| = 8$ .

The other measures for teacher 2 are:  $k2 = -3$ ;  $k3 = 1$ ;  $k4 = -3$  so the total  $IS_2 = -12$ . Similarly, for student 23,  $k2 = 7$ ;  $k3 = -1$ ;  $k4 = 11$  and the total is  $LS_{23} = 18$ . The total distance between teacher 2 and student 23 is  $D_{2,23} = |-12 - 18| = 30$

## 4. Results

All members of the research population (students and teachers) filled out the  $LS$  and  $IS$  questionnaires, respectively. The  $IS$ - $LS$  distances were calculated for each student and his or her teacher. Students' grades in the final exams of 17 courses were collected and correlations between  $IS$ - $LS$  distances and these grades were analyzed. Table 4 presents an example of the measured  $IS_{2K}$  for teacher T2 and  $LS_{iK}$  for his students (S23 to S31). The detailed calculations of distances  $D_{2iK}$  and  $D_{2i}$  between this teacher's  $IS$  and his students'  $LS$  as well as the correlation with the students' grades also appear in Table 4. The last row of Table 4 is identical to the fifth row of Table 5. The final results of all the research population are presented in Tables 5-7.

Table 5 presents the correlation matrix for the high school. It presents correlations between stu-

**Table 2.** Cronbach's alpha of each dimension in the  $LS$  questionnaire

Dimension	Visual-Verbal (k=4)	Sequential-Global (k=3)	Sensing-Intuitive (k=2)	Active-Reflective (k=1)
Cronbach's alpha (n = 165)	0.699	0.636	0.696	0.680

**Table 3.** Questionnaire items associated with  $LS$  dimensions

k	Dimension	Items in the questionnaire	'a' preference	'b' preference
1	Active-Reflective	1,5,9,13,17,21,25,29,33,37,41	Active	Reflective
2	Sensing-Intuitive	2,6,10,14,18,22,26,30,34,38,42	Sensing	Intuitive
3	Sequential-Global	4,8,12,16,20,24,28,32,36,40,44	Sequential	Global
4	Visual-Verbal	3,7,11,15,19,23,27,31,35,39,43	Visual	Verbal

**Table 4.** Detailed calculations of the  $IS$  for teacher T2, and the  $LS$  for students S23-S31, the  $IS$ - $LS$  distances and the correlations between students' grades and distances

Participant	k1	k2	k3	k4	Total	D2,i,1	D2,i,2	D2,i,3	D2,i,4	D2,i	Grades
T2	-7	-3	1	-3	-12						
S23	1	7	-1	11	18	8	10	2	14	30	70
S24	5	7	-3	5	14	12	10	4	8	26	80
S25	1	7	-1	5	12	8	10	2	8	24	92
S26	5	3	1	3	12	12	6	0	6	24	55
S27	1	-7	1	7	2	8	4	0	10	14	85
S28	1	-11	1	7	-2	8	8	0	10	10	80
S29	-3	11	1	11	20	4	14	0	14	32	70
S30	5	-7	1	7	6	12	4	0	10	18	88
S31	1	5	3	7	16	8	8	2	10	28	57
Correlations						0.04	-0.14	0.04	-0.01	-0.48	

**Table 5.** Correlation coefficients between *IS–LS distance* and students' achievements in the high school

Correlation Matrix – High School						
Teacher no., Studying group, Course taught		Correlation coefficients of <i>distances</i> vs. achievements				
		$D_{jik}$				$D_{ji}$
	N	k = 1	k = 2	k = 3	k = 4	Total
Teacher 1, Grade 10, Digital systems	12	-0.25	0.20	0.56	0.31	-0.08
Teacher 1, Grade 11, Programming	10	0.25	-0.95	-0.69	0.37	-0.19
Teacher 1, Grade 12, Group 1, Micro-controllers	9	-0.09	-0.33	-0.48	0.21	-0.09
Teacher 1, Grade 12, Group 2, Programming	16	0.00	-0.47	-0.28	0.02	-0.58
Teacher 2, Grade 12, Group 1, Analog electronics 1	9	0.04	-0.14	0.04	-0.01	-0.48
Teacher 2, Grade 12, Group 1, Analog electronics 2	9	-0.27	0.30	-0.24	0.52	-0.06

**Table 6.** Correlation coefficients between *IS–LS distance* and students' achievements in college 1

Correlation Matrix – Practical Engineering College 1						
Teacher no., Studying group, Course taught		Correlation coefficients of <i>distances</i> vs. achievements				
		$D_{jik}$				$D_{ji}$
	N	k = 1	k = 2	k = 3	k = 4	Total
Teacher 3, Second year, Instrumentation 1	29	-0.25	-0.12	-0.45	-0.16	0.01
Teacher 3, Second year, Instrumentation 2	29	-0.26	0.04	-0.36	0.17	-0.17
Teacher 4, Second year, Control	29	-0.42	0.00	-0.38	0.28	-0.27
Teacher 5, Second year, Analog electronics	29	0.35	-0.08	-0.14	-0.13	-0.16
Teacher 6, Second year, Micro-controllers	29	-0.24	-0.08	-0.25	0.03	-0.47

**Table 7.** Correlation coefficients between *IS–LS distance* and students' achievements in college 2

Correlation Matrix – Practical Engineering College 2						
Teacher no., Studying group, Course taught		Correlation coefficients of <i>distances</i> vs. achievements				
		$D_{jik}$				$D_{ji}$
	N	k = 1	k = 2	k = 3	k = 4	Total
Teacher 7, Second year, Group 1, VHDL	26	-0.34	-0.09	-0.22	0.10	-0.06
Teacher 7, Second year, Group 2, VHDL	12	0.43	-0.03	-0.45	0.10	0.34
Teacher 7, Second year, Group 2, Programming	12	0.47	-0.23	-0.43	0.06	0.25
Teacher 8, First year, Group 1, Analog electronics	14	-0.37	0.09	-0.25	0.08	-0.20
Teacher 8, First year, Group 2, Analog electronics	26	-0.02	-0.28	-0.16	-0.14	-0.21
Teacher 8, First year, Group 3, Analog electronics	11	-0.28	-0.10	0.03	-0.32	-0.35

dents' grades and the calculated *distances*  $D_{jik}$  for each dimension. The matrix also contains the correlations between students' grades and total *distances*  $D_{ji}$ .

Tables 6 and 7 present the same information as Table 5 for the students and teachers of practical engineering colleges 1 and 2.

As shown in Tables 5–7, there is no single  $D_{jik}$  or  $D_{ji}$  with consistent significant negative correlations. Moreover, even when it comes to the same teacher and the same student group, e.g., Teacher 2—Grade 12—Group 1 studying the analog electronics 1 and 2 courses (Table 5), the correlations are not consistent. There are some meaningful negative correlations here and there; however, this is not sufficient to support the argument that a close *distance* between the teachers' *IS* and the students' *LS* contributes to students' achievements.

## 5. Discussion

The current research is a true field experiment in which the *IS–LS distances* between each student

and the corresponding teacher were measured and correlated with the grades given by the teacher to the student. This is done for 165 students, constituting eight groups that took 17 courses in three schools and taught by eight teachers. The correlations between *IS–LS distances* and students' achievements were calculated for each group. The prior assumption was that the smaller the *distance*, the higher the student's grade would be. If true, substantial negative correlations should appear in the correlation matrixes. The correlations reached in this research for the high school and the two colleges do not support the assumption that a close match between *IS–LS* contributes to students' achievements. Previous research [4, 5] with a research population of 74 students and five teachers from two high schools and a college produced the same results. The previous research, however, used the older version of *ILS*; therefore, the researchers repeated the experiment with the newer four dimensions *ILS* [6].

These results match Lemire's [12] statement that professionals should be skeptical about claims in the

*LS* research area. The results concur with Felder's assertion that students' *LS* are not stable. They may change over time, and may vary from one subject to another [17, 27]. For instance, there is a wide consensus among all the *LS* researchers surveyed in the literature review section above that some people prefer visual presentation while others prefer verbal presentation. Accordingly, if we examine the Visual-Verbal ( $k = 4$ ) dimension in Tables 5–7, we should see significant negative correlations—which we do not.

The results of the current research do not support even the assumption that a short *distance* in this dimension leads to higher grades. The fact that the research was conducted in a real world situation, a group context, supports Salton's [in 31] opinion that even if there is evidence to validate the practical relationship between *LS* and learning effectiveness, it means nothing in practice. This assertion is in line with this paper's conclusions, which deal with the relationship between *IS-LS distance* and achievements in the field.

The contention that close *IS-LS* leads to better achievements has taken on a life of its own, as a result of which some researchers, e.g., [23], believe that teachers should make every effort to match their *IS* to their students' *LS*. The current research results do not support this hypothesis. Above all, it is vital to remember that the main goal of good teaching is encouraging the student to learn. The student is the one who is responsible for learning [32, 33]—which brings us to Felder's suggestion of designing a curriculum in such a way that during instruction it addresses every style to a reasonable extent [35]. Such a setting may help students reach a better understanding because they will have absorbed the learning material through different modalities.

## 6. Conclusion and suggestions

The current paper does not suggest that different *LS* and *IS* do not exist. The reader, nevertheless, should remember that *LS* and *IS* are non-stable preferences, as argued in the literature. Teachers must also remember that at any particular moment, there are different students with different *LS* in their classrooms. Therefore, adopting Felder's idea of diversifying teaching methods in class is the most valid suggestion that the current paper supports.

The population involved in the current research are electronic engineering students. Therefore, a possible way to broaden the research limitations, is to conduct similar studies in different disciplines and different populations.

An additional direction for further relevant research is to develop a behavioral questionnaire

that asks students about how they learn rather than how they prefer to learn, and try to correlate students' behaviors to their achievements. Such a questionnaire must, first, be validated and its reliability should be proved before it can be used.

Another direction is to investigate whether students who taught by a diversity of teaching methods achieve higher academic grades. For such a study, a diversity factor can be defined as a combination of number of teaching methods and the time distribution among the different methods. This suggestion fits Felder's idea of designing a curriculum so that during instruction, it addresses every style to a reasonable extent.

The results of the future studies suggested above might contribute to curriculum design and teaching methods that can help improve students' achievements.

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