

# My Students Don't Learn the Way I Do

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## Abstract

An understanding of how students learn can facilitate the design and creation of better teaching materials. Instruments that attempt to measure learning styles are many and varied, and their use can be controversial. This paper reports on a study of the learning styles of students in an introductory programming course, and a comparison with the learning style of their instructor. We conclude that it is not necessary to cover all possible learning styles, so long as students' learning preferences *include* the modalities presented in materials.

*Keywords:* learning styles, VARK, computing education, introductory programming

## 1 Introduction

It would be ideal if the materials created by an instructor were suitable for all students in a course. An introductory programming course will typically include students from a variety of disciplines, who will presumably not all have the same preferred manner of learning. It is difficult to know a great deal about students in such a course, and consequently how to cater for them.

This paper begins by describing some identified learning styles, the inventories designed to measure them, and some past research involving learning styles in the computing education domain. An exploratory study of introductory programming students' learning styles is described, with the broad goals of comparing the learning preferences of students and instructor, and of determining what learning preferences should be catered to by the course materials. Results of the study are then reported and discussed.

### 1.1 Learning Styles

It is generally agreed that students learn in different ways. However, there is little consensus on the best way to measure students' *learning styles*. There are many learning style inventories and questionnaires, some of which are strongly validated while others are as unreliable as a personality quiz in a glossy magazine. The inclusion of learning styles assessment within educational practice has been criticised by some psychologists due to the lack of evidence to justify the validity of the instruments used (Pashler et al., 2009). Yet this criticism is not universally warranted, as some learning style inventories have been heavily tested. Some claim reliable

internal consistency, which is one measure of validity. Some learning style inventories are based on established psychological theories. An excellent review of popular learning style inventories, with measurements and comparisons, is presented by the Learning and Skills Research Centre of the UK (Coffield et al., 2004).

One obvious difference between inventories is the choice of dimensions that they attempt to measure. Jackson's Learning Styles Profiler proposes four learning types linked to personality: initiator, reasoner, analyst and implementer (Jackson, 2002). The Herrmann Brain Dominance Instrument looks at use of parts of the brain to classify learners (or, more correctly, thinkers) as theorists, organisers, innovators or humanitarians (Herrmann, 1989). The validity of placing learners 'in a box' by categorising them is accepted by some researchers and rejected by others, but is not the focus of this study.

Some inventories, such as the Myers-Briggs Type Indicator (Myers & McCaulley, 1985), assume that learning style is stable, a relatively unchanging part of a learner. Others, for example Kolb's Learning Style Inventory (Kolb, 1999), assume that learning style is a changing aspect of the learner, influenced by the learning environment. Again, this distinction is not being questioned here.

Some learning style inventories attempt to collect together other inventories. Some do so to provide a sensible combination, while others seem to try to cover as many dimensions of a learner as possible. The Index of Learning Styles, formulated by Felder and Silverman, combines some of the work of Kolb and Myers-Briggs to categorise learners as active/reflective, sensing/intuitive, visual/verbal, and sequential/global (Felder, 1996).

Related to learning style is learning approach. While learning styles describe how learners prefer to receive instruction, a learning approach defines how students undertake learning. For example, Biggs (1987) categorised learners as taking on a deep or surface approach in a course. Later, Entwistle (1998) extended this to include, most significantly, a strategic approach, and a number of other categories. This study will focus only on learning styles, not on learning approaches.

Learning styles are measured by asking the learner to complete a questionnaire, choosing responses they feel are appropriate for themselves. Through analysis of responses, a student's learning preferences can be identified according to the dimensions of the particular inventory.

### 1.2 The VARK Questionnaire

The VARK Questionnaire (Fleming, 1995) measures preference for receiving instructional material. VARK differentiates preferences as:

- Visual,



Figure 1. The VARK Questionnaire presented online

- Aural,
- Read/Write, and
- Kinesthetic.

A learner with a visual preference prefers to learn by seeing graphs, charts, and flow diagrams. “Sometimes they will draw maps of their learning sequences or create patterns of information. They are sensitive to different or changing spatial arrangements and can work easily with symbols” (Fleming, 1995, p. 2). A student with an aural preference is best served when information is communicated through speech. Students with a read/write preference receive information best when it is presented in written form. In the generally understood sense, kinesthetic learners prefer to learn using their tactile senses. The VARK sense is a little more general: “kinesthetic individuals prefer to learn through direct practice, which may also involve the other perceptual modes” (Leite et al., 2010, p. 326).

The VARK preferences can be related to sensory modalities (eg tactile, visual and auditory), which are studied experimentally within educational psychology (Conway & Christiansen, 2005; Mayer, 1997).

The VARK Questionnaire is available online (Fleming, 2009b) and free for all to use. The questionnaire consists of 16 questions, each with four possible responses. A participant must answer at least 12 questions and can choose from none to all four of the responses for each question (see Figure 1).

After analysis of responses, a learner can be identified as having a single preference, being bimodal, trimodal, or accepting all four modes (this is referred to as a VARK preference). Analysis of the tens of thousands of completed online questionnaires (Fleming, 2009c) produces the distribution of participants with these combinations shown in Table 1.

The distribution of single preferences can be broken into specific preferences and presented together with multiple preferences to create an overall picture of typical

Table 1. Single and multiple VARK preferences

Profile	Proportion
Single preference (V, A, R, K)	37.0%
Bi-modal (VA,VR,VK,AR,AK,RK)	15.5%
Tri-modal (VAR,VAK,ARK,VRK)	12.5%
All four modes (VARK)	35.0%

learning preferences as shown in Figure 2.

At the end of the questionnaire, participants are given their calculated profile. They are also given the opportunity to respond to this information, to state whether they believe the calculated profile matches their perceived learning preference. Results of agreement are reported as a measure of validity on the VARK site (Fleming, 2009a). Such results are certainly not a formally accepted measure of validity, and would perhaps be better described as a measure of internal consistency, but general agreement is certainly more encouraging than general disagreement. The responses and the proportion of responding participants from the general population who have chosen each response are shown below.

- Match = 58%
- Don't Know = 38%
- No match = 4%

The VARK Questionnaire is claimed to be “an excellent vehicle for opening a dialog on the differences that might exist in the way individuals prefer to learn, but the statistical properties are not sufficient for its use as a research tool” (Fleming, 2009c). In that light, measurements gained from the VARK Questionnaire (and perhaps from all such inventory related tools) should be taken as a way to begin understanding how students’ learning preferences can be catered for in a course, and not used to predict or infer outcomes for individual students.

The VARK Questionnaire has recently undergone testing for validity: “many individuals are interested in using the VARK as an input or outcome measure in research, and it is these uses that require a more rigorous evaluation of its psychometric properties” (Leite et al., 2010, p. 324). The questionnaire was found to be a valid instrument for identifying learning preferences: “those who wish to use the instrument as a way of helping students identify their preferences should feel

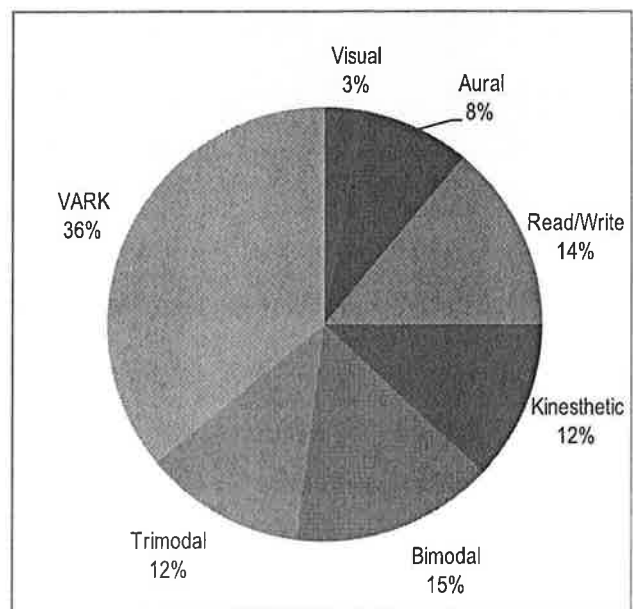


Figure 2. Typical VARK learning style preferences (Fleming, 2009c)

comfortable in this use” (p. 336). However, Leite and his colleagues did not suggest that the VARK Questionnaire could be used as an instrument to predict success in learning. It would therefore be invalid to attempt to infer student attributes based on VARK preferences. In our study, student preferences are measured as a general consideration to inform our teaching, not as a way of concluding anything about individual students.

### 1.3 Learning Styles in Computing Education

A number of instructors of computing have used learning style questionnaires with their students and have reported their findings.

Thomas et al. (2002) used the Felder-Silverman Learning Style Index to measure the learning styles of their students in a sequence of two introductory programming courses. They compared learning styles captured at the beginning of the sequence with exam and final marks. They found significant differences in exam marks between reflective and active learners, with reflective learners performing significantly better. Also, verbal learners statistically out-performed visual learners in the exam. In overall results, on the four dimensions of the Felder-Silverman LSI, students who were reflective, intuitive, verbal, global learners performed better than students from other groups. Using these findings, Thomas et al. indicated that they would create materials that would “appeal to different kinds of learners’ preferences” (p. 36) and encourage students to reflect on their learning styles and strengthen less preferred modes of learning. They also suggested they would follow up with a further analysis in later offerings, to see if their efforts had improved student outcomes. In later cohorts, the mix of learning preferences had changed and was no longer comparable to the original study (Thomas, 2009).

Researchers from the University of Joensuu (now merged into the University of Eastern Finland) measured the learning preferences of students enrolled across a number of undergraduate computing courses (Bednarik & Fränti, 2004). The group used the VARK Questionnaire to determine students’ learning preferences with a view to exploring whether students with a particular preference would perform better across the courses they were studying. Their results showed no strong evidence that students who preferred a single modality would be more successful across courses. Students with a balanced VARK profile had slightly better performance. The group also measured the learning preferences of teachers, and found a variety of learning styles among these staff. In each course, students with profiles that matched those of the instructor tended to perform better than other students.

A multi-national study (de Raadt et al., 2005) looked for predictors of student success in introductory programming courses at eleven institutions in three countries. A number of cognitive and articulation tests were applied, including Biggs’s approach to learning (Biggs, 1987). No single measure emerged as a significant predictor of success, but the strongest correlation with success was found to be the students’ learning approach: learners with a deep approach to learning were found to be more successful and those with a surface approach were found to be less successful.

Apart from these few studies there does not appear to have been much exploration of learning preferences in computing education. While our data arises naturally from the course and the way it was taught, the scarcity of other work was a motivating factor in our subsequent analysis of the data.

## 2 The Study

We have collected and analysed the learning preferences of both on-campus students and external students over three offerings of a first programming course.

### 2.1 Motivation

Awareness of the variety of learning preferences in a particular cohort allows an instructor to design or adjust course materials to suit that cohort. Zualkernan (2007) describes how the Felder-Silverman Learning Style Index can be used to evaluate the resources for introductory programming students, and how this can be fine-tuned to improve learning outcomes.

If a cohort includes a large proportion of students with a particular learning preference, it would be wise to cater for that learning preference. Where there is a variety of learning preferences, materials should be presented in multiple formats.

In the study described by Bednarik & Fränti (2004), students with learning preferences similar to their instructor’s generally performed better. It is therefore useful to know the instructor’s learning preferences and whether this matches those of the students in the course. At the same time, an awareness of differences in learning preferences between instructor and students can help to ensure that particular groups of students are not advantaged or disadvantaged.

Our study began as an exploratory one, guided by the following questions.

1. What were the students’ learning preferences?
2. How did these preferences compare to those of the instructor?
3. What modalities presented in materials would cater for students’ preferences?

### 2.2 Method

Learning styles were measured in order to determine whether materials presented to students suited their learning preferences and whether the learning profiles of students matched that of their instructor. This was conducted assuming that preferences shift from one cohort to another, so results applicable to the current cohort will not necessarily represent future cohorts. Measurement of learning style is not an empirical science, so the results were not used as part of a statistical proof or for any form of inference.

The VARK Questionnaire was chosen to measure learning preferences because:

- it is a validated tool;
- it is simple to calculate and compare results;
- it is free, online and easily accessed by students; and
- results are easily related to materials presented to students.

Students were invited to complete the questionnaire during an initial workshop and to report (copy and paste) in a discussion forum their score for each preference and their learning preference calculated by the VARK site. These results were collected and recalculated to check that values were reported accurately. Students were also asked if they agreed with their rating and if they thought it reflected how they learn.

This collection of learning preferences was carried out as part of the teaching, not as part of a research project. The principal purpose was in fact to encourage participation in the online forum for the course. There was no inducement for students to take part, and students who declined to do so were not penalised in any way.

### 2.3 Context

The course used as a context for this study is an introductory programming course conducted by a single instructor.

The course is offered in two modes: on-campus and external. On-campus students attend workshop classes in a computer laboratory. Each workshop consists of short periods of didactic teaching mixed with practical exercises. External students follow the same format, but the didactic teaching is presented as written text with complementary recorded video snippets. Over the three semesters that the study has been running there have been 394 students, with 71% enrolled as external students and 29% studying on campus. Students in both modes were invited to complete the VARK Questionnaire and submit their results.

The initial design for materials had a focus on kinesthetic learning through practical exercises. Written material was also presented, mixed with occasional visual diagrams. Recorded video snippets containing slides and instructor audio and video were inserted into the materials as an alternative to text.

## 3 Results

There were 394 students enrolled over the three semesters. Of these, 226 voluntarily completed the VARK Questionnaire and posted their learning preference results, giving a participation rate of 57%.

Participants' acceptance of their calculated learning style was analysed. Learning styles data was used to explore two principal issues: the match between the learning preferences of the students and the instructor, and the general pattern of the students' learning preferences.

### 3.1 Agreement with Learning Style

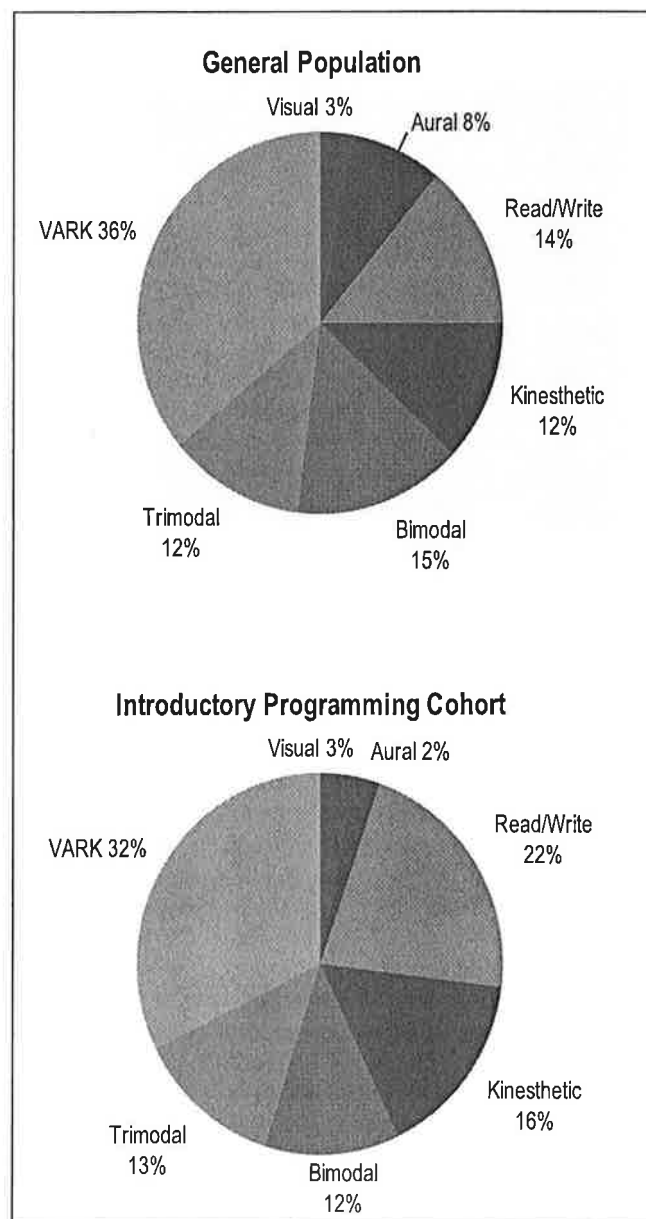
Participants were asked if they agreed with their calculated learning style. Positive responses can be used as a small measure of the validity of the VARK instrument. Over the three cohorts, 78% of students who posted their learning style also gave their agreement. Unsure students were grouped with students who gave an indefinite response in the "don't know" category. Results are shown in Figure 3 alongside the levels of agreement given by the general population as reported at the VARK site.

**Table 2. Agreement with calculated learning style**

Response	Participants	General Population
Yes	72%	58%
Don't know	18%	38%
No	10%	4%

**Table 3. Learning Preferences of students by mode**

Preference	On-campus (n=60)	External (n=166)	All
Visual	2%	2%	2%
Aural	2%	2%	2%
Read/Write	29%	19%	22%
Kinesthetic	19%	16%	16%
Bimodal	13%	13%	13%
Trimodal	10%	16%	14%
VARK	25%	32%	30%



**Figure 3. Comparison of participants (n=226) to general population**

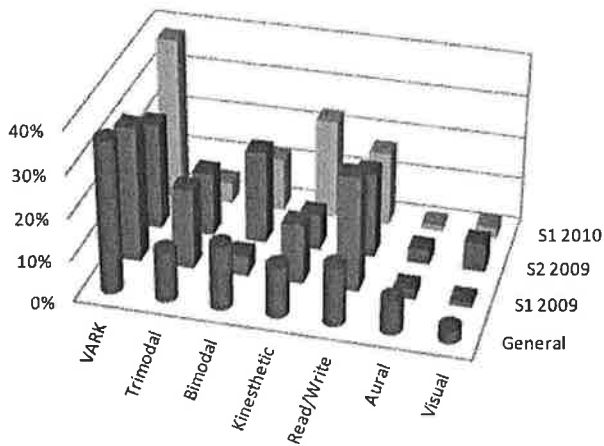


Figure 4: Comparison of all three cohorts (n=85, 60, 81) and general population

Compared to the general population, participating students were more confident about whether they agreed with their calculated learning style, with fewer indefinite “don’t know” responses. There were more definite “yes” and “no” responses, with the yes responses strongly outweighing the no responses.

### 3.2 Instructor’s Learning Preference

After completing the VARK Questionnaire, the instructor’s learning preference was determined to be a single preference for kinesthetic learning. This indicates that the instructor has a preference for learning through doing (perhaps not abnormal for a programming instructor). It should be noted that this is the instructor’s learning preference and not necessarily his teaching preference, although it seems likely that these would be related.

Table 3 shows that only 16% of students share the instructor’s preference for kinesthetic learning.

### 3.3 Student Learning Preferences

The learning preferences, shown in Table 3, show sizeable populations of multi-modal VARK students (30%), and read/write students (22%).

Figure 3 shows a comparison between students in the course and the general population as reported on the VARK site. Students in the course were more likely to have a read/write preference than normal. Fewer students in this cohort have an aural preference, compared to the general population. However, there appear to be more similarities than differences between the two breakdowns, suggesting that the learning preferences of students in this course are not markedly different from those of the ‘general population’ of tens of thousands who have taken the VARK test.

The initial conclusion from this breakdown of preferences was that the kinesthetic aspect of the course materials was appropriate, but that the read/write aspect should not be overlooked. This conclusion will be further discussed in the discussion section.

#### 3.3.1 Separate Cohorts

At first sight, the learning preferences of separate cohorts did not appear to match. Figure 4 shows the preferences

Table 4: Example VARK scores from a selection of students (vs, s, and m indicate very strong, strong, and mild)

Calculated Student Preference	Student Scores			
	Visual	Aural	Read/write	Kinesthetic
Kinesthetic (vs)	1	3	2	13
Kinesthetic (s)	6	6	5	13
Kinesthetic (m)	4	8	8	13
Kinesthetic (m)	1	4	4	7
Bimodal	5	7	12	12
Bimodal	1	6	2	7
Bimodal	2	3	5	6
Trimodal	15	2	14	12
Trimodal	4	5	5	2
VARK	13	9	13	12
VARK	6	4	6	6
VARK	3	12	9	6
VARK	3	4	5	5

of each of the three cohorts, again alongside those from the VARK general population.

There are some clear differences between cohorts; for example, a high proportion of read/write preferences in S1 2009 (first semester of 2009) and of kinesthetic in S1 2010 (first semester of 2010). But at the same time there are similarities between the cohorts, similarities that should be mined for useful information.

In all three cohorts the proportion of read/write preferences is noticeably higher than that of the general population. This perhaps not surprising, as a read/write preference is possibly associated with academic success of the sort required to enter a university course.

The high proportion of multimodal or VARK preferences appears comparable with that of the greater population, as does the low proportion of visual preferences.

But in fact the most useful feature of the learning preference analysis is one that is hidden in Figure 4. The real lesson for the designer of learning materials lies in the bimodal and trimodal preferences, and will be elaborated in the following section.

#### 3.3.2 Bimodal and trimodal preferences

At first we readily accepted the broad preference groupings that are reflected in most of the tables and figures to this point. People’s learning preferences can be single-mode (visual, aural, read/write, or kinesthetic), bimodal (any two of those four), trimodal (any three of those four), or VARK (all four). Single-mode preferences are accompanied by a strength indicator of mild, strong, or very strong.

The algorithm for distinguishing preferences is given on the VARK website and the breakdown provided to users includes an explicit score for each of the four primary preferences, allowing further analysis.

Table 4 shows the calculated preferences and the individual scores for a selection of students in order to demonstrate how preferences are determined. The



strength ratings of the first four students show that the strength of the preference depends not on the absolute score in that preference but on the differences between that preference and the others. A preference is given when the difference stepping down between a stronger and next strongest modality is less than or equal to a proportional margin. The margin is greater when there are more points overall; the more points the greater the allowed margin (1 to 4). For example, the first four students are kinesthetic because their kinesthetic scores are higher than their other scores by a proportional margin. A student shows a multi-modal preference when there are smaller steps between modalities. For example, the first trimodal student totalled 48 points, allowing a margin of 4 points between modalities; this succeeds from 15 to 14 and 14 to 12, but not 12 to 2, so the student has a trimodal preference. It is not clear why this method was chosen; one might ask why the third VARK student is considered VARK when their strongest preference differs greatly from their weakest.

Of more interest, though, is that a single-mode preference by no means excludes the other modes. While the third and fourth students in Table 4 have a clear preference for the kinesthetic, they would also appear to be quite comfortable with both aural and read/write materials, whereas the first student is markedly less so. This sort of information is obscured by the simple single-mode classification.

But what the instructor really needs to know in order to develop good teaching materials is not which modes the students prefer, but which modes they do not prefer. If a particular learning resource were purely read/write, it would probably disadvantage the first kinesthetic student and the second bimodal student in Table 4, but the rest of the students would appear able to cope with it. If a learning resource were purely visual, it would probably cause difficulty for half a dozen of the students – including two with the multi-modal VARK preferences. Therefore we need to consider not which learning preferences are present in a cohort, but which are absent: which students will be unable to cope with material designed for specific learning preferences?

Rather than observing that 27% of the students have a single-mode read/write preference, we ask how many students include a read/write preference in either single-mode read/write, bimodal, trimodal, or VARK. The answer is a rather more impressive 73% of all students tested. This, and the figures for the other three modes, are summarised in Table 5.

It is clear from Table 5 that if learning materials were designed to suit read/write students only, 27% of students would not learn well from them. Likewise, if learning materials were designed to suit kinesthetic students only,

**Table 5: proportion of students showing each preference either as a single mode or as part of a multiple mode**

Preference	Students
Visual	50%
Aural	44%
Read/write	73%
Kinesthetic	67%

33% of students would face some difficulty. We now explore which students, if any, would be disadvantaged by learning materials designed to suit both read/write and kinesthetic preferences.

If materials were designed to suit both of these groups, the 73% of students whose preferences include read/write and the overlapping 67% of students whose preferences include kinesthetic should be able to learn effectively from them. Who does that leave? It leaves the students with single-mode visual preference, the students with single-mode aural preference, and the students with bimodal visual and aural preferences. Every other student has preferences that include either read/write, kinesthetic, or both. Of the 226 students who completed the VARK test, only 14 fall into this visual/aural set, as summarised in Table 6.

Inspection of the preferences in Table 6 shows that in fact 11 of the students have reasonable scores in both read/write and kinesthetic, two have reasonable scores in read/write, and one has a reasonable score in kinesthetic. In other words, while these 14 students (6% of the total) have clear preferences for the visual, the aural, or both, they should be reasonably able to cope with materials designed to cover both read/write and kinesthetic preferences.

## 4 Discussion

The conclusions of this study discuss the level of student agreement with measured VARK preferences, alignment with the instructor's learning style, and an examination of how participating students' preferences can be catered for.

### 4.1 Agreement

Of the participants who indicated agreement, 72% agreed with their calculated learning style and only 10% disagreed. This level of agreement is above that indicated by the general population, providing some confidence in the results gathered in this study.

**Table 6: individual VARK scores for all students whose preferences do not include read/write or VARK**

Preference	Visual	Aural	Read/write	Kinesthetic
Aural	2	8	4	6
Aural	2	7	5	2
Aural	2	8	6	4
Aural	5	11	4	4
Aural	3	10	6	6
Visual	13	5	6	5
Visual	8	3	3	2
Visual	12	3	7	8
Visual	14	6	6	6
Visual	13	7	8	8
Visual	11	1	8	6
Visual	7	2	3	4
VA bimodal	7	6	3	4
VA bimodal	6	5	3	3

## 4.2 Difference between instructor and students

There was only a 16% alignment between the instructor's kinesthetic learning preference and those of students in the course. However, where the instructor had a single learning preference (kinesthetic), many of the students had multi-modal profiles which included kinesthetic as a modality to some degree. Indeed, subsequent inspection shows that with VK, VAK, VRK, AK, ARK, RK and VARK students, who all include kinesthetic among their preferences, the overlap is a rather more impressive 67% of all students.

The instructor is confident that the design of the course materials was influenced by his kinesthetic learning preference. Initially, there was a plan to reduce the importance of textual content of the course materials. After coming to know the learning preferences of students, and particularly the strong read/write preference of over a quarter of the first cohort, the textual content was instead enhanced rather than reduced.

This study showed that it is unwise to assume that students in a cohort share the same learning preference as their instructor. As we observe in the title of this paper, my students don't learn the way I do – and it would be a mistake to design my learning materials on the assumption that they do.

When focusing on the difference between students enrolled in different study modes, interesting differences emerged. A much larger proportion of on-campus students than of external students prefer kinesthetic learning. It may be that these students have chosen to study on campus, in some part, because of this aspect of their learning. It was surprising that a larger proportion of on-campus students had a read/write preference, compared to external students, who are often presented with materials primarily as text in external courses. A larger number of external students had a broader VARK preference than on-campus students. Perhaps students willing to undertake external study have to be better prepared to accept materials in a variety of forms. However, these conclusions might be putting the cart before the horse. Do students choose to study in a particular mode because of their learning preferences or because of other circumstances such as geographical location, family, employment, etc? If it is the latter, we should be wary of attributing any significance to the relationship between the students' modes of study and their learning preferences.

## 4.3 Catering for students' learning styles

While our initial focus was the foregoing comparison between the lecturer's and students' learning styles, we now believe that the real message of this work lies not in the analysis of what preferences students have but in the complementary analysis of what preferences they do not have. When a system pigeonholes students learning styles or preferences into single categories, an inevitable conclusion is that in order to be effective, learning materials must cover all of those categories. The great advantage of the VARK system, which we did not realise until we were well into the analysis phase of our work, is its recognition that single preferences do not necessarily suit the bulk of the population, and its provision of actual

scores in each category so that further analysis can be conducted.

While it might indeed be a good idea to design learning materials to suit all possible VARK modalities, or all preferences in any other system, we are now in a position to conclude that learning materials designed to cover both read/write and kinesthetic preferences will suit all students in the three cohorts we have studied. Learning materials do not have to be all things to all people: it is enough that they be at least one usable thing to each student.

Given the similarity between the VARK distribution of our three cohorts and the general population, we believe that our conclusion can be generalised to other courses, unless their instructors conduct VARK assessments and find that their profiles differ significantly. If learning materials are designed with good textual material to suit the read/write modality and good hands-on experience to suit the kinesthetic, such materials should suit the learning preferences of virtually all of the students.

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