PRELIMINARY SURVEY ON VISUAL/VERBAL DIMENSION IN FELDMAN-SOLOMAN MODEL AND ASSESSMENT FORMAT IN AN INTRODUCTORY PROGRAMMING COURSE

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Abstract

This paper describes an investigation into the learning styles of first-year computer programming students in relation to different types of assessment modes. We initiated this preliminary research based on our observation over a number of years of student's who were being taught programming for the first time. All students are required to complete the same types of assessment tasks, regardless of their learning styles, educational and cultural backgrounds. We hypothesize that the misalignment of learning to teaching styles may have an impact on student learning. Hence, the aim of this study is to investigate the correlation of learning styles with assessment format. We present the background of our study together with a brief overview of the learning styles and current research. Finally, we discuss our findings that we have found very little dependence between the learning styles and assessment modes.

Introduction

Across many different higher educational programmes, students enrolled in a Computer Science or Information Technology undergraduate degree are frequently required to undertake at least one introductory programming unit as part of their first-year course requirements. We have observed over the past few years that learning programming, especially for the first time, is often perceived and sometimes proven to be a daunting and arduous task for a majority of students, particularly for students who have no or very little experience in dealing with analytical and systematic problem-solving tasks in their prior educational backgrounds. Our main intent is to find out the effect of the students' learning styles in relation to various assessment modes.

In a university environment and setting such as ours where effects of internationalization are rather prominent, the students' come from different educational backgrounds and environments where they would have adopted their respective learning styles during the course of their primary and secondary education. In the context of a first-year programming unit, there are a number of key research questions that may be investigated. For example, are the respective learning styles suitable in the current educational environment? Is there a need to adapt the teaching style according to the learning styles and how do you balance between the different learning styles of student in a classroom against the appropriate teaching styles? Do the different assessment modes affect student who shown a preference towards a specific learning style? In addition to the diverse education backgrounds, there is also underlying need to consider the language barrier. Although all students have to meet specific English language requirements before being allowed to enroll in the course, nonetheless, there may still exists a language barrier when it comes to comprehension and understanding of assessments.

Given the limited resources and time constraints, we have decided to focus our research on the study of the learning styles of students who are introduced to programming for the first time in relation to different assessment methods. In particular we studied the effects of using matched assessment tasks according to student learning styles. Although an important question, at this stage we will not constrain the study towards the issue of whether there is an impending need to cater to the diverse cultural and ethnic origins of students from different countries. We have decided to first determine whether there is any dependence between learning styles and assessment formats in general for all students, regardless of their educational and cultural backgrounds.

The subject area identified for this research is a first-year Computer Programming where students are required to attend three hours of lecture weekly, a one-hour tutorial session and a two-hour programming practical lab session. The programming language that is taught for the unit in context is the Java programming language which is based on an object-oriented paradigm.

The total number of students enrolled in the unit is 38 students. However, due to constraints, we were only able to record the learning styles from 23 students. Out of the 23 students who were included in this study, 14 students were local students whilst the remaining number of students came from different countries such as Indonesia, Singapore, Vietnam, Middle East, China and Africa. Therefore, it is evident that these students have been through different education settings and environments throughout their primary and secondary education. Our initial observation is that the nature of interaction and communication styles of students from around the South East Asian region often differs significantly to students from other regions.

Next, we will discuss the learning style model adopted for use in our investigation, followed by a discussion on the results that we have obtained. We will then present the methodology used for developing and designing the different assignments modes in line with the outcome that we obtained from the initial learning styles investigation. This is followed by a discussion on the results as well as our conclusions and future work.

Learning Styles

Learning style can be described as "the complex manner in which, and the conditions under which, learners most efficiently and most effectively perceive, process, store and recall what they are attempting to learn"[1]. Alternatively, it may also be described as an individual's preferred way of learning[2]. Despite the general understanding of learning styles, there is little agreement on what these styles are. Popular learning style models include VARK[3], Honey & Mumford[4], Dunn[5], Felder-Soloman[6], Kolb[7] and Myer-Briggs[8].

The Felder-Silverman model[9] was developed originally as an aid to minimizing the mismatch between teaching and learning styles in Engineering. Similarly, the VARK[3] and Honey & Mumford's models[4] were also developed and used as a model for learning styles. The VARK model[3] is centered on the four learning categories – Visual, Aural, Read/Write, and Kinesthetic. These learning preferences can be considered as being similar to Felder-Silverman's categorization of visual, verbal, sequential and active learners. Conversely, Kolb's[10] experiential learning cycle model is more focused on how information is processed rather than the preference for learning or taking in information. Honey and Mumford[4] developed their model based on a variation of Kolb's learning cycle. Their research demonstrated that learning styles are roughly equivalent to the stages of the learning cycle. The learning styles that they defined which are activist, reflector, theorist and pragmatist, also fall within Felder-Silverman's model of active, reflective, deductive and sensing learners. The Myer-Briggs[8, 11] model was developed as an indicator of personality and psychological type, and not specifically for learning theory development. For this research, we adopted the Felder-Silverman learning styles model because the model subsumed most of the other models and it was specifically developed for science and engineering education.

Briefly, Felder and Soloman[6] described the characteristics of the four dimensions of learning styles as such. Active learners prefer to be doing something as opposed to reflective learners who tend to ponder over the matter first. Sensing learners tend towards learning facts and are good at hands-on work whilst intuitive learners prefer discovery and innovation. Visual learners prefer visual presentations as opposed to verbal learners who learn more from written and spoken explanations. Finally, sequential learners learn effectively from logical linear steps and global learners absorb material at random and have the ability to suddenly grasp the entire picture.

In order to determine the students' learning styles, we required students to undertake the online Index of Learning Styles[12] survey. This was accomplished during the practical programming sessions where each student's learning style was noted as the higher value within each dimension of the learning style model for each student in attendance. As we have mentioned earlier, we were only able to obtain the learning style dimensions of 23 students.

Assessment Modes

Based on our observations of the approaches that students' take towards assessment tasks and how they react and provide the solutions, our aim was to find out whether there is any relationship between learning styles and assessment modes.

There has been numerous works in the area of the relationship between learning and teaching styles as discussed in the learning styles models. In Mayer[13], it was demonstrated that particular combinations of media promoted learning whereas others had a detrimental effect. There have been comparatively less research on matching assessment tasks to learning styles. As an example, a visual learner may have a preference towards learning through diagrams, charts or other forms of visual aids. In this case, would an assessment that is text-based be a fair assessment task for a visual learner? What are the consequences when visual learners who prefer information presented as images are presented with materials in dense text?

Consequently, our aim in this research was to evaluate the impact of matched assessments tasks against learning styles. Therefore, we hypothesize that the misalignment of learning to assessment modes may have an impact on student learning. We want to find out if there is any impact when the visual learner is assigned an assessment that is predominantly text based. Specifically, we want to analyze the effect of the situation where a learner is assigned a task or given an assessment that does not match his or her learning style. Therefore, we evaluate our research in terms of the effectiveness of the matched assessment tasks that was created as well as whether the different assessments were successfully administered.

Once we had identified the learning styles at the initial stage, we then proceeded to create a set of assessments designed to assess the same concept or topic but presented in a different manner matching the different learning styles. A second set of assessments was also designed to cater to students with opposing learning styles. We contend that it is possible that assessment tasks be customized according to the personal learning style. Most of the time assessments are in standard textual format, where the tasks mainly require written answers. Therefore, it was actually quite challenging to create assessments in other modes.

The research involved designing a set of matched assessment tasks for the different learning style dimensions identified. We faced numerous difficulties in designing and selecting the tasks to match the learning styles. There were two main requirements which we sought for the matched assessment tasks. Firstly we wanted to look at questions that were not too difficult for students, ideally we wanted something that they would have already learnt and worked on during the course of their study before the assessment was administered. The rationale for this is that we wanted to ensure that incorrect answers are not due to the lack of knowledge. On the other hand, we did not want the tasks to be too simple. Secondly, we had to design a task that could be presented in different formats in order to match the respective learning styles, yet retain the same level of cognitive difficulty. We mulled over the design choices over a few weeks. There was also the question of format suitability to the assessment tasks, and the question of how the tasks should be distributed to the students.

As part of the initial stage in designing the assessment tasks, we had to choose a topic to be assessed based on the criteria that the topic should preferably be based on the current curriculum and the students should be reasonably familiar with the topic. Once we had decided on the topic, we proceeded with designing the actual assessment tasks itself. The tasks were designed with two primary conditions in mind. The first condition was that the task should not be too challenging, or else we would not be able to determine whether the assessment format played a role in the answers provided by the students, or the student simply could not work out the answers regardless of the presentation format. Secondly, the task, or equivalent task should be presented in the different formats without being seen to provide additional information towards a solution.

We finally settled on two assessment questions. The first question was centered on Object-Oriented class design with the second question on testing a student's understanding of a program fragment.

Next we had to decide how the assessments were to be administered. For example, we had to determine whether we should hand out individually matched assessment to the students, i.e. one matched assessment to a student. Or alternatively, we could get each student to work on multiple assessment tasks for all available learning styles. This means that if we had identified four learning styles, then each student is requested to complete all four assessment tasks.

After much deliberation, we decided to give each student multiple assessment tasks so that each student is given the opportunity to work on a similar question but in different presentation styles. We opted for this as we wanted more data to work with so that we could have data on both the matched styles as well as data on the unmatched styles. To supplement the matched assessment tasks, at the end of the task, we had also distributed a short questionnaire that allows the student to comment and provide feedback on the differences of the tasks given.

Students' Learning Style

The initial phase of the project involved determining the learning styles of the students enrolled in the unit. This was easily accomplished from the Felder and Soloman self-administered online learning styles and strategies questionnaire[6]. According to the Felder and Soloman model, there are 4 dimensions of learning styles – Active-Reflective, Sensing-Intuitive, Visual-Verbal and Sequential-Global. Students are classified on a scale, where the scores within each dimension indicate whether the student is well-balanced or has a moderate preference or very strong preference for each respective learning dimension.

If the score on a scale is 1-3, we record that as well-balanced on the two dimensions of that scale. If the score on a scale is 5-7, then it is considered a moderate preference for one dimension of the scale. If the score is between 9-11, then it is considered to be a very strong preference for one dimension of the scale.

We recorded the learning styles of 23 students and a summary of the percentage of students' learning styles scores with respect to the four dimensions is shown in Figure 1. The table in the figure shows the percentage of students within each dimension with the actual number in brackets.

The Active-Reflective dimension refers to the mental processing preference model. Active learners prefer active experimentation or inclusive participation to learn, such as discussions and experimentation. Reflective learners prefer examination and manipulating the information introspectively, and require time on their own to go over the information acquired rather than work in groups[6].

Sensors from the Sensing-Intuitive dimension prefer to work with concrete facts, but intuitors prefer working with concepts and abstraction. A visual learner is one who prefers visual information such as pictures, diagrams, charts, plots, animations, and so on. Verbal refers to a learning style that is preferential to language whether spoken or written[6].

Felder and Solomon advocate that it is desirable to have a balance between the two learning strategies in a dimension [6]. Based on our findings, 65% of students are balanced within the active-reflective dimension, 56% are balanced within the sensing-intuitive dimension and 60% are balanced within the sequential-global dimension. For the visual-verbal dimension, a majority of students seem to show biasness as visual learners, with 60% showing a moderate or strong preference towards visual learning. There also appears to be a small percentage of students' who demonstrate a moderate preference towards sequential learning and sensing learning.

Results on Learning Styles Assessment Presentation Format

Based on the learning style questionnaire, it was established that majority of the students are Visual-Verbal learners. Therefore we decided to perform the test for this dimension. Additionally, it is easier to design assessment tasks that are biased to either visual or verbal.

The assessments we have designed were compiled into two separate worksheets – Worksheet A and Worksheet B. Worksheet A contains a question presented in a textual format to work out the class diagram of a given scenario. The question describes the working of the control and navigation deck of the fictitious space craft. Similarly, Worksheet B involves generating the class diagrams of a GPS (global positioning system) Map navigator. In this case, instead of a textual description, the diagram and photo of its various functions is presented.

Question 2 of both worksheets involves understanding a program fragment. Question 2 of Worksheet A has a textual description of program while Question 2 of Worksheet B has diagrammatic explanation of the program. Students have to work out certain conditions of the program. We assumed that Question 1 on both worksheets should be relatively easy for the students and they should know the general expected answers. However, Question 2 is more challenging, and they have not faced this type of question before.

The results of Question 1 for both worksheets A and B are shown in Figure 2. The table is separated into two sections, the upper half shows students who have some visual orientation, and the lower half those with verbal orientation. The scores of their answers are in Column A and B for worksheet A and B respectively. The scores are over 10. We only present the scores for the first question as the second question had too few responses.

	Active	**Reflective**	**Sensing**	**Intuitive**	**Visual**	**Verbal**	**Sequential**	**Global**
Balanced	39% (*9*)	26% (*6*)	43% (*10*)	13% (*3*)	22% (*5*)	8% (*2*)	52% (*12*)	8% (*2*)
Moderate Preference	17% (*4*)	13% (*3*)	26% (*6*)	13% (*3*)	30% (*7*)	5% (*1*)	30% (*7*)	5% (1)
Strong Preference	5% (*1*)		5% (*1*)		30% (*7*)	5% (*1*)	5% (*1*)	

Figure 1: Percentage of Learning Style Scores in Each Dimension.

As can be seen from Figure 2, all results are significantly better for Worksheet B than Worksheet A. It indicates that there no relationship between learning styles and assessment formats that can be asserted in this test. Even though we cannot assert any relationship, we can show that almost every student prefers a more visually presented assessment question.

No	*Active*	*Reflective*	*Sensing*	*Intuitive*	*Visual*	*Verbal*	*Sequential*	*Global*	*A*	*B*
1		5	1		**7**		1		1	2
2	5			1	**7**		3		4	5
3	5		5		**7**		3		1	2
4	3		1		**9**		1		3	1
5	1			1	**7**		3		3	3
6	**11**		1		9		3		2	2
7		7	5		**11**		3		1	6
8	1			1	**9**		5		3	5
9		3		**5**	**5**		**5**		4	5
10		5	3		5		**9**		1	3
11	3		1		3		**5**		1	1
12		1	**7**		3		5		0	6
13		1	**7**		3		5		0	3
14	1		**3**		1		**3**		1	4
15	1		1			**3**	**3**		0	1
16	1		1			**9**	7		1	6
17	1		**5**			1		1	3	5
18	1			**5**		**5**	1		0	1

Figure 2: Worksheet A and B Scores and Learning Styles.

	Active	*Reflective*	*Sensing*	*Intuitive*	*Visual*	*Verbal*	*Sequential*	*Global*	*Feedback*
1		5	1		7		1		B
2	5			1	7		3		B
3	5		5		7		3		A
4	3		1		9		1		C
5	1			1	7		3		B
6	11		1		9		3		A
7		7	5		11		3		B
8	1			1	9		5		B
9		3		5	5		5		C
10		5	3		5		9		B
11	3		1		3		5		B
12		1	7		3		5		B
13		1	7		3		5		B
14	1		3		1		3		B
15	1		1			3	3		A
16	1		1			9	7		B
17	1		5			1		1	C
18	1			5		5	1		C

Figure 3: Self Assessment Feedback and Learning Styles
(A = Prefers Question A, B = Prefers Question B, C = Neither).

Discussion

Overall, we only managed to obtain the necessary data on 20 students out of the 40 students enrolled in the unit so the analysis is not a full representation of all students.

Assuming our methodology is correct, it would appear that learning styles are not a factor in assessment formats. Learning styles as the name implies refers to the preferred cognitive approach in learners to acquire and understand information. However in performing assessments, the students are not in a learning mode so they are not processing information to develop knowledge and understanding but rather applying their knowledge. In this context, the learning styles do not apply. The feedback (shown in Figure 3) also confirms this conclusion.

While there is no correlation between learning styles there is a correlation between their stated preference and worksheet score. Analyses of the students own assessment of their preferences (visual or textual) and their scores in Worksheet A or B indicates a high correlation. 85.7% (12 out of 14) who indicated either A or B as their preferences has score equal or higher in the worksheet corresponding to their indicated preference.

Another aspect that needs to be factored is the students' grasp of the language. In the feedback provided, some students expressed that the words and text in Worksheet A is slightly difficult to understand. Given this, then, perhaps we can rationalize from the results that visually oriented information provides a better information channel throughput, where more information is provided as input for processing.

However, there is a possibility that the learning style dimensions are not stable. Students who are more adaptable, can adopt different styles at different situations to their advantage. Hence, the classification of categories could possibly be fluid and cannot be determined easily. A better explanation can be found using Curry's model[14]. In Curry's model, learning styles are grouped in concentric circles, with the core being more stable and the outward layers less stable. The inner layer is the cognitive personality style, and following that is the information processing style layer and the outermost is instructional preferences layer. Taking in consideration of Curry's model, then what we have identified are the instructional preferences of the students. And this also implies that the Felder-Silverman model position in Curry's model is not with the outer layer, but in either the information processing or cognitive personality style layer.

It may seem that the number of students with verbal preference is far too few to make any significant conclusions; still it seems clear that visually presented worksheet is preferred.

Conclusion

We did observe a bias towards visually oriented format in assessment and questions independent of learning styles preference as determined by the Felder-Soloman model. Even though in performing the assessment tasks the students engage in problem understanding, problem solving, critical thinking, planning and analysis, they are not acquiring and assimilating information for understanding. This could be argued that in performing assessment tasks, students are engaged in problem solving mode, and learning styles preferences do not apply.

Indirectly, this lends support that the Felder-Soloman model is a cognitive personality learning model. This also suggestively leads to the onion-layered model as proposed by Curry. The visual bias that we have uncovered is the top-layer physical modality preference that is different and independent from the learning styles.

As we had indicated earlier, we hope to continue our research by further considering the different education and cultural backgrounds of students in relation to their learning styles and assessment modes. This will enable us to consider and adapt the teaching style to further enhance student learning according to their learning preferences.

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Appendix 1.

WORKSHEET A
NAME:_______________________

Question 1
[Note: This description is excerpted from http://www.geocities.com/Area51/Rampart/5407/conn.htm]

The U.S.S ENTERPRISE NCC-1701-D Flight Control console, often referred to as Conn, is responsible for the actual piloting and navigation of the spacecraft.

There are five major areas of responsibility for the Flight Control Officer:
- Navigational references/course plotting
- Supervision of automatic flight operations
- Manual fight operations
- Position verification
- Bridge liaison to Engineering department

Flight and Navigation Control

Navigational references/course plotting. The Flight Control console displays reading from navigational and tactical sensors, overlaying them on current positional and course projection. Conn has the option of accessing data feeds from secondary navigation and science sensors for verification of primary sensor data. Such cross-checks are automatically performed at each change-of-shift and upon activation of Alert status.

Manual flight operations. The actual execution of flight instructions is generally left to computer control, but Conn has the option of exercising manual control over helm and navigational functions. In full manual mode, Conn can actually steer the ship under keypad control.

Thrusts control system. Although the actual vector and sequence control of the system is normally automated, Conn has the option of manually commanding the RCS system or individual thrusters.

Conn also serves as a liaison to the Engineering department in that he/she is responsible for monitoring propulsion system status and providing system status reports to the commanding officer in the absence of an engineering officer's presence on the bridge.

Flight Information Input

There are five standard input modes available for specification of spacecraft flight paths. Any of these options may be entered either by keyboard or by vocal command.

In each case, Flight Control software will automatically determine an optimal flight path conforming to Starfleet flight and safety rules. Conn then has the option of executing this flight plan or modifying any parameters to meet specific mission needs. Normal input modes include:

Destination planet or star system. Any celestial object within the navigational database is acceptable as a destination, although the system will inform Conn in the event that a destination exceeds the operating range of the spacecraft. Specific facilities (such as orbital space stations) within the database are also acceptable destinations.

Destination sector. A sector identification number or sector common name is valid destination. In the absence of a specific destination with a sector, the flight path will default to the geometric center of the specified sector.

Spacecraft intercept. This requires Conn to specify a target spacecraft on which a tactical sensor lock has been established. This also requires Conn to specify either a relative closing speed or an intercept time so that a speed can be determined. An absolute warp velocity can also be specified. Navigational software will determine an optical flight path based on specified speed and tactical projection of target vehicule's flight path. Several variations of this mode are available for use during combat situations.

Relative bearing. A flight vector can be specified as an azimuth/elevation relative to the current orientation of the spacecraft. In such cases, 000-mark-0 represents a flight vector straight ahead.

Absolute heading. A flight vector can also be specified as an azimuth/elevation relative to the center of the galaxy. In such cases, 000-mark-0 represents a flight vector from the ship to the center of the galaxy.
Based on the information provided above, you, as the senior object-oriented design architect, have to design the software that will simulate the above USS Enterprise control console. The software simulator will serve to train future officers on Enterprise-class starship.

Your first task is to select out the major object classes of the system. You should also show any links between classes such as inheritance, aggregation, etc. Show your design on the reverse of this page.

Question 2
The concept of Loop Invariant is often used in proof of correctness of programs. In iterative programs it is a condition that is true at the beginning and end of each iteration of a loop, hence invariant.

For a while loop, the condition is just below the while loop condition, eg. "while(x<0){", and at the end of the loop just before the last "}".

This means that it is a condition, or a relationship between variables that is also true. The Loop Invariant captures the relationship among variables that change in value as it loops but maintaining its invariant relationship even as variable values changes.

In the short program below, the Invariant is marked I.

```
int sum=0;
int k=0;
while(k<n)
{ // I: sum = summation of integers from
0..k
  k++;
  sum=sum+k;
}
```

Now your turn, what is the invariant for this program below:

```
int count=0;
int temp=1;
while(count< number)
{
  count++;
  temp=temp*base;
}
```

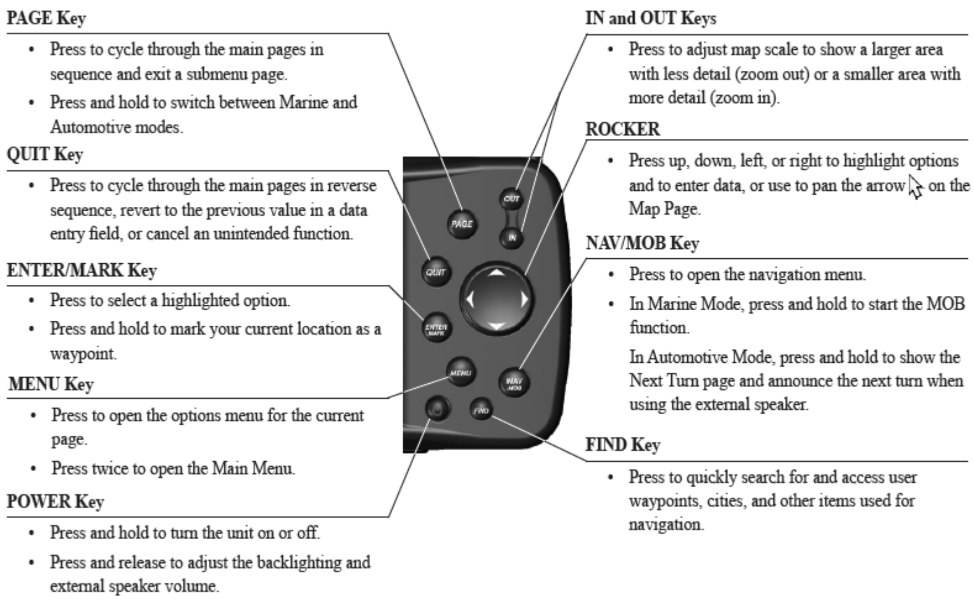
Hint: what is a stable (invariant) relationship between temp, base and count that is always true?

Appendix 2.

WORKSHEET B **NAME:________________________________**

Question 1.

Design the OO Classes necessary to simulate the device shown below. You only need to provide the class diagram.



{Note: Adapted from a product manual. Source Unavailable.]

Question 2

Consider this program fragment below (with line numbers on the left).

```
1 temp=i;
2 for(j=i+1;j<n;j++){
3    //loop invariant here.
4    if(A[j]<A[temp])
5      temp=j;
6 }
```

Assume that A[] stores up to n random integers.
When j< temp, then

..	j	..	temp	..

If A[j]<A[temp], replace temp with j.

After replacing, temp is now at old j; and A[temp] now has a smaller value.

..	temp	…	..

What can you say about the value stored in temp? The concept of Loop Invariant is often used in proof of correctness of programs.

In iterative programs it is a condition that is true at the beginning and end of each iteration of a loop, hence invariant.

What is the loop invariant for this program?

Biographical Information

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