Adaptive Education based on Learning Styles: Are Learning Style Instruments Precise Enough?

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Abstract—Investigating the efficiency of learning style instruments is significant because it is a widespread technique and it enriches the understanding of the challenges of integrating such instruments into adaptive education systems. The results showed that current learning style instruments depend only on the textual form of information to present items; this might be leading to a bias in the measurement of learning styles as the textual forms of information are more suitable for verbal students than for others. The purpose of this paper is to investigate the precision of learning style instruments and the challenges of integrating them into adaptive education systems. This research followed a quantitative research approach. First, a new learning style instrument was developed using different forms of information (Figures, Charts, and Equations). Then, the preferred learning style of fifty students was measured twice, initially, by using the newly developed instrument and subsequently by using a VARK instrument, the results of both were compared.

Keywords— adaptive education, learning style, learning style instruments

1 Introduction

Research on the use of information technology in computing based education has indicated that students have different abilities and needs. In other words, they tend to learn in different ways. These preferences are called learning styles [1-3]. It is argued that the matching of teaching styles with student preferred learning styles is useful to improve student learning outcomes [1, 4-8]. Many researchers believe that students should know more details about their preferred learning styles because that will help them to be more attracted, engaged and motivated in educational sessions [2, 5, 9-13]. Although a number of learning style instruments were developed over the last few decades, these instruments still have many challenges in terms of efficiency [14]. The question of to what extent learning style instruments are precise is critical for their successful use in adaptive education systems. Previous studies have shown that the current learning style instruments depend heavily on textual forms of information to

present items, and this property may make it more appropriate and attractive for verbal types of learners. Consequently, this might be leading to a bias for verbal learners, more than others, such as visual and active learners [15].

The main aim of this study is to investigate the impact of using different forms of information (visual and active) for building learning style instruments, and the impact of that on the accuracy of measurement. To reach this, the following research hypothesis is proposed:

H0: constructing learning style instruments using different forms of information (visual and active content) will not impact the measuring of learning preferences.

H1: constructing learning style instruments using different forms of information (visual and active content) will impact the measuring of learning preferences.

Although learning styles were defined more than half a century ago, and a number of studies have been conducted during this period, there are relatively few studies focusing on the type of content, which could be used to build the learning style instruments. In 2017, Alzain studied qualitatively, the possible impact of content type on the accuracy of learning style instruments [15]. This study complements the existing research in this topic. This research is significant because it enriches the understanding of the challenges involved in designing and developing such instruments. This research can also contribute to improve the understanding of the challenges of integrating these instruments into adaptive education systems.

The following sections of the paper will address, the literature, research methodology, data collected, results and discussion and finally areas of further research.

2 Literature review

As a research area, investigating the ways in which student learning varies has attracted the interest of researchers due to the need to improve education systems so this can better cater for all students. This section reviews the main concepts related to the research field from the following three aspects: the learning style instruments, adaptive education systems, and how instruments were integrated into the adaptive education systems.

2.1 Learning style

The concept of style in the learning process indicates the fact that students differ as to how they receive new information and how they interact with that information [16]. Therefore, students who have visual preferences tend to obtain more knowledge from the materials that depend on the visual forms of information, whereas the same material will be more useful for the learners with verbal preferences if these materials are represented using text and audio. Moreover, some students tend to learn more through ‘doing’, whereas some others prefer to ‘think and reflect’. These preferences are called learning styles [1-3]. Over the last few decades, a number of learning style models and instruments were developed. In this research, five well-known models [17] are investigated for comparison purposes. See Table 1

Table 1. Differences and similarities of learning styles.

Model	Definition of Learning Style	Number of dimensions	Instrument	Content	Instrument mechanism
Felder–Silverman	"The characteristic strengths and preferences in the ways individuals take in and process information" [17]	5	Index of Learning Style (ISL)	Text only	Select only one answer from two alternatives
VARK	"An individual's characteristics and preferred ways of gathering, organizing, and thinking about information" [17]	2	VARK Questionnaire	Text only	Select one or more answer from the four alternatives
Kolb	"Generalized differences in learning orientation based on the degree to which people emphasize the four modes of the learning process" [18]	2	Learning Style Inventory (LSI)	Text only	Rank-order set of items
Dunn-Dunn	"The way in which individuals begin to concentrate on, process, internalize, and retain new and difficult information" [19]	5	Productivity Environmental Preference Survey (PEPS)	Text only	Likert-type scale
Gregorc	"Distinctive and observable behaviours that provide clues about the mediation abilities of individuals and how their minds relate to the world and, therefore, how they learn" [20]	4	Gregorc Style Delineator (GSD)	Text only	Rank-order set of items

Based on the previous investigations, it is necessary for a number of important points to be noted:

1. Content of existing instruments:
   (a) All of the existing learning style instruments were built using only the textual form of information, which is considered more suitable for verbal learners than others [15]. Consequently, these instruments might be more suitable and motivating for the verbal type of students than others.
2. Instruments Mechanism: each instrument consist of a set of items, each of which has a number of answers (alternatives) and the participant needs to select the best answer(s):
   (a) In the instruments that depend on selecting only one answer from a set of alternatives: This mechanism seems to be inconsistent with the argument that learning styles are not dichotomies (either/or) options, because learners could have aspects of say visual and verbal learning at the same time.
   (b) In the instruments that depend on selecting more than one answer from a set of alternatives that correspond to different learning styles: this mechanism could not be fully accurate, because the selected answers have the same weight of significance statistically, while learners could fall under both poles (say visual and verbal) of one dimension but with varying level of preference (pure, moderate and mild).

(c) In the instruments that depend on ranking set of alternatives: ranking a set of answers without the possibility of giving the same level of importance for more than one answer at the same time could be a restrictive mechanism.

2.2 Adaptive education systems

Although students have different preferences, goals, experience and knowledge, traditional educational systems provide the same static content for all student [21]. Therefore, in considering the individual differences between students, adaptive systems have been harnessed in the education field. Adaptive educational systems have been defined as "technological component of joint human–machine systems that can change their behavior to meet the changing needs of their users, often without explicit instructions from their users" [22]. This generation of education systems can provide the student with materials that are adapted especially to preferences, goals, experiences or knowledge of the subject [21, 23, 24].

2.3 Incorporating learning style into adaptive education systems

An adaptive education system aims to take into account the individual differences among students by providing the materials, activities and teaching methods that best accommodate student needs and abilities. However, we also need to know: what student features can be used for achieving the adaptation process, "adaptation to what?" [2]. In recent work, Özyurt [25] within the scope of adaptive education systems, 69 studies published from 2005 to 2014 were analysed. This demonstrated that the learning style is one of the most common and important parameters that could be used when designing adaptive learning environments, to consider the individual differences among students. The results of this study reveal that: forty-eight studies out of sixty-nine (69.6 per cent) depend on learning style instruments to determine student learning preferences in order to achieve the adaptation process, whilst remainder (twenty-one studies, 30.4 %) used different techniques and methods such as artificial intelligence methods and classification algorithms. With reference to learning styles models and instruments that have been employed in these studies, the results show that, the Felder-Silverman learning style model was the most preferred model (42%), followed by the Kolb model (14.5 %). More recently, Truong investigated integrating learning styles in adaptive e-learning systems by reviewing 51 studies published from (2004 to 2014), the results of this study show that, the Felder-Silverman learning style model was the most preferred model (70.6%), and then the VARK model (9.8%) [12]. A number of previous adaptive systems that depend on learning style instruments were investigated for comparison purposes. See Table 2.

Table 2. Summary of previous adaptive education systems

System	Instrument	Preferences	Evaluation
CS383	index of learning style instrument	sensing-intuitive, visual-verbal and sequential-global dimension	No formal experimental research has been conducted to evaluate it (informal assessment) [26]
INSPIRE	Honey and Mumford questionnaire. (Student profile can be updated manually)	Reflector-activist	An empirical study with twenty-three participants was conducted [27]
Arthur	Determine by the system (No psychometric instrument)	visual-interactive, auditory-text, auditory-lecture, text-only presentation	An empirical study with 89 participants was conducted [27]
EDUEC	MIDAS Multiple intelligence inventory	logical/mathematical, verbal/linguistic, visual/spatial and musical/rhythmic	two empirical studies with (117 participants) were conducted [26, 28]
ILASH	Index of learning style questionnaire (ILS)	global/sequential dimension	An empirical study with twenty-two participants was conducted [29, 30]
3DE	Honey and Mumford questionnaire (students has privileges to decide whether follow his/her preferred learning style or try an another alternative)	Activists, Reflectors	A cross-cultural empirical study was conducted and 40 participants from each country (Italy, France, Spain, Finland) have participated [31, 32]
iWeaver	Building Excellence Inventory	Global, analytical, impulsive, reflective, visual, auditory, kinaesthetic	A workshop with sixty-three learners was conducted [26, 33]
AHA!	LAG-XLS generic adaptive language. Students update change his/her profile using special forms.	Providing pre-defined strategies for (Active-Reflective, Verbalizer-Imager, Global-Analytic and Field Dependent-Field Independent), authors can build their own strategy	An empirical study with thirty-four participants was conducted [24, 34, 35]
TANGOW	Index of learning style questionnaire (ILS) and updating the student profiles using student actions, background, age and language.	sensing-intuitive and sequential-global	No formal experimental research has been conducted to evaluate this system [36-38]

3 Research method

This section highlights the research methods harnessed for this study.

3.1 Adaptive education systems

The main aim of this research is to investigate the effect of using different forms of information (visual and active) in constructing learning style instruments, and how

this will effect the efficiency and effectiveness of these instruments. This investigation was conducted in the School of Science and Technology at Nottingham Trent University, and the data was collected from 50 students: of the 50 students who agreed to engage, 10 were female and 40 male. Only 6 participants were studying at postgraduate level and the other 44 students were undergraduates.

Before starting the experiment, the researcher provided the participants with a brief idea about the research and discussed with them some related issues such as:

1. The concept and theory of learning styles;
2. Dimensions of learning styles;
3. The previous learning style models and instruments.

The preferred learning style of participants was then measured twice. Initially, by using the newly developed instrument and subsequently by using a VARK instrument. The results of both were compared and data was analysed using SPSS Version 22. A paired t-test was conducted to determine if there were any significant differences between student learning styles measured by the two instruments.

3.2 Methods of data collection

On the first iteration, the preferred learning style of the participants was measured using the ALSI instrument. This instrument was developed using different forms of information such as (Figures, Charts, and Equations) [15]. Figure 1 shows a sample of the ALSI instrument.

Secondly, the preferred learning styles of participants were measured using the VARK questionnaire, which is constructed using text only. Figure 2 show a sample of the VARK questionnaire.

Both instruments consist of 16 questions, each of which has four responses, and the participants needs to select the answer(s) that best fits their preference (they are allowed to choose more than one answer).

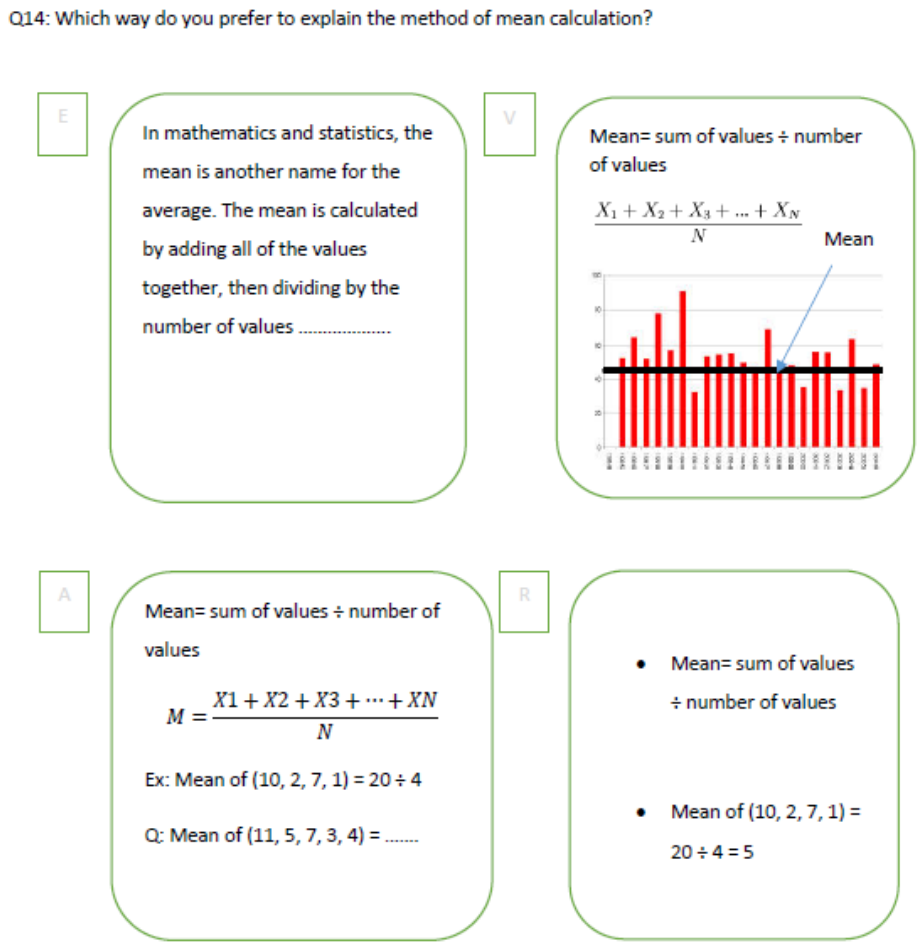

Fig. 1. ALSI instrument sample.

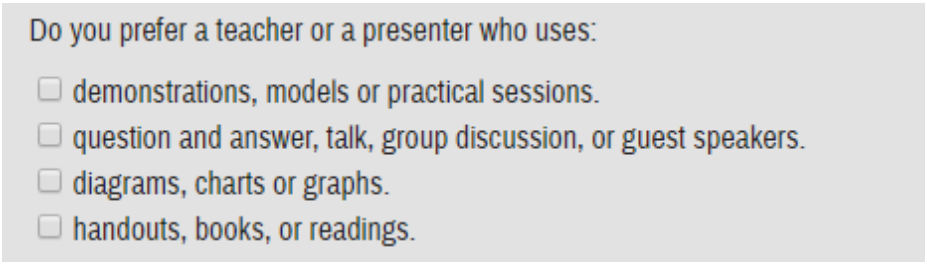

Fig. 2. VARK questionnaire sample.

4 Results

The preferred learning styles of participants were measured using both instruments. Table 3 illustrates the distribution of participant preferences based on the ALSI instrument and the VARK questionnaire. For visual impact, this data is displayed in figure 3.

Table 3. Participants distribution based on learning styles using the VARK instrument and the ALSI instrument.

Score	Visual		Verbal		Active		Passive	
	ALSI	***VARK***	***ALSI***	***VARK***	***ALSI***	***VARK***	***ALSI***	***VARK***
Pure	24	1	4	1	25	7	2	1
Moderate	25	17	33	20	25	28	32	13
Mild	1	32	13	29	0	15	16	36

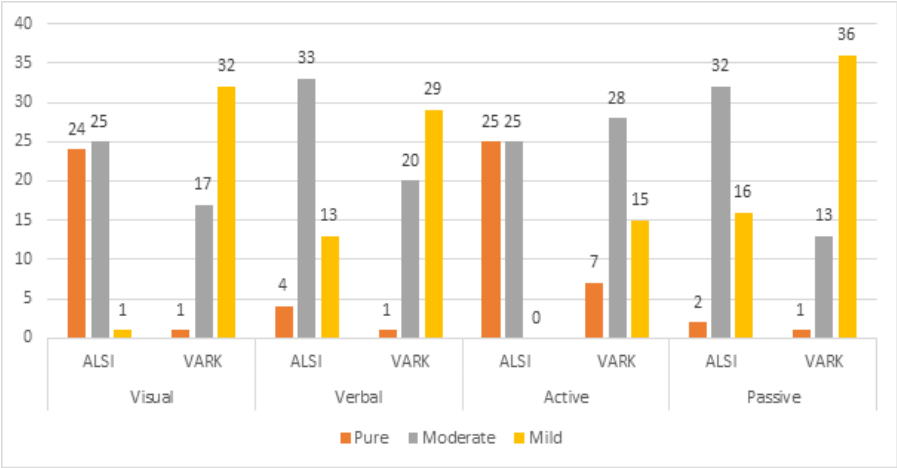

Fig. 3. Visual presentation of participant distribution based on learning styles.

With reference to the research hypothesis, "constructing the instruments of learning style using the different forms of information (visual and active content) will not impact the measuring of learning preferences?". A paired t-test was conducted to determine if there were any significant differences between the mean student learning styles scores.

Based on the results of the Paired t-test, there were significant differences among students preferred learning styles, whereby the value of (p) in each dimension is less than 0.5:

1. Visual style ($t = -12.94$, $p = 0.000$).
2. Verbal style ($t = -3.87$, $p = 0.000$).
3. Active style ($t = -9.91$, $p = 0.000$).
4. Passive style ($t = -6.03$, $p = 0.000$).

These results confirm the alternative hypothesis (H0), and prove that using different forms of information (visual and active content) to construct learning style instruments will significantly impact the measuring of learning preferences.

The effect size was also measured for each individual scale. The results of Cohen's d revealed that the highest effect size (d = 2.37) was in the visual scale followed by the active scale (d = 1.72) and then the passive scale (d = 1.15), and the lowest effect size (d = 0.71) was in the verbal scale.

5 Discussion

This research investigated empirically the effect of using different forms of information such as visual and active content to constructing learning style instruments, and the impact of that on the efficiency and accuracy of these instruments. Generally, the results showed that using visual and active content in the instrument construction has a considerable influence on the measurement of learning styles. The results showed that the number of students whose learning style was characterized as "visual" increased significantly when they used the ALSI instrument, which was built using visual and active content. This result aligns with a concept of learning style theory, which states that the visual type of learner responds strongly to visual forms of information (figures, charts, pictures… etc.). The results also showed an increase in the number of students whose learning style was characterized as "active" when they used the ALSI instrument, that contained active content. In contrast, the "verbal" and "passive" preferences have not seen as big a difference as the "visual" and "active" types. This may be interpreted by the fact that the textual content was extensively used in the construction of previous instruments.

Although, these results have emerged from quantitative experiments they are supported by the qualitative research conducted in 2016 [15]. However, there is a need for more investigation in terms of the impact of instrument content types on the accuracy of measuring learning styles. Since we know that these instruments have used by most adaptive educational systems for the purpose of matching the teaching style with student preferred learning styles [25]. Accordingly, before we build our teaching approach based on learning style instruments, it is important to investigate to what extent these instruments measure what we think is being measured.

An important implication of these findings is that the possibility of changing the learning preferences according to the content of the instrument that is used to measure theses preferences. Therefore, although matching the teaching strategies with student preferred learning styles has been found to have a positive impact on student performance, it seems to be critical to build our teaching systems in light of the consequences of the instrument, especially if the instrument itself does not fully reflect reality.

6 Conclusion

The findings of this study indicated that the scores of measuring the preferred learning styles of the participants varied according to the approach in the questions presented in the learning style instrument. In this case, the researcher argues that items of the instruments ought to be presented in a manner which corresponds to different learning styles, in light of the fact that the learners will respond strongly to patterns of information which correspond to their preferred style. Consequently, this will provide some solutions for the problems that might arise from using only textual information to construct learning style instruments.

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