READINESS FOR THE USE OF TECHNOLOGY FOR EFFECTIVE LEARNING VIA THE VDS:

Case of the United Arab Emirates

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Abstract. Review of the literature indicated that today's knowledge-driven economy demands a workforce equipped with complex skills and attitudes such as problem solving, meta-cognitive skills, critical thinking and lifelong learning. Such skills can be acquired if learning and teaching are guided by the constructivist and cognitive learning theories. In particular, the constructivist approach emphasises effective learning processes based on learning by doing and collaboration. This approach is congruent with use of technologies, such as Virtual Design Studio (VDS), for the purpose of architecture education in design courses, but such use is lacking in the United Arab Emirates (UAE). It is thus important to assess the extent to which the constructivist and cognitive theories are implemented in teaching design courses in the Architecture schools of the UAE. It is also important to assess the effectiveness of employing technology in general and VDS in particular in implementing these theories. The author intends to study the relationship between effective learning on one hand and using VDS in implementing the constructivist and cognitive approaches on the other hand. Thus, the author conducted a preliminary study to gain a basic understanding of the difficulties, approaches, attitudes, perceptions, and motivation related to the learning of design in architecture schools in the UAE. Second, the investigation was designed to assess the extent to which the students would be interested in the use of sophisticated technology in the teaching and learning environment in the UAE architecture education schools in order to achieve effective learning. The study has been conducted in the United Arab Emirates University (UAEU). Methodology used for this was the focus group method. In addition to the focus group interviews with the UAEU students, unstructured individual interviews with lecturers from UAEU and the American University of Sharjah (AUS) have been carried out. Data analysis showed that students were not satisfied with the current teaching

methods based on traditional lectures. It was concluded that students were ready to practice effective learning of design via the intermarriage of VDS and the constructivist and cognitive approaches. An ambiguity that remained was whether students were ready for assessment methods which are consistent with the constructivist approach.

1. Introduction

Governments are becoming increasingly aware of the positive effect of education on the growth of economy that is best described as knowledge driven economy (McCain, 2002; O'Neill, Singh, O'Donoghue, 2004; Resnick, 2002). As a result, the higher education (HE) institutes are undergoing fundamental changes in order to meet the demands of today's job market (Jochems, Merrienboer and koper, 2004; O'Neill, Singh, & O'Donoghue, 2004). A major challenge for HE is to develop instructional strategies that promote students' complex skills such as critical thinking, meta-cognitive skills, general problem solving skills, creative problem solving skills, and attitudes related to teamwork, collaboration, and lifelong learning. As today's networked world requires a workforce that uses technology as a tool to increase productivity and creativity, employees are required to collaborate, work in teams, and share information across global networks in order to examine issues from multi-disciplinary points of view (Hawkins, 2002).

International research in the field of higher education (HE) revealed the need for critical changes in teaching strategies for the purpose of providing the student with the skills needed to meet the challenges of the current and future job market. Several studies were conducted to examine the suitability of teaching strategies from the perspective of learning theories. A multitude of other studies examined the usefulness of technology in teaching (e.g. Anderson et al., 2001; Garrison, 2003).

Developing complex skills requires providing the students with opportunities to construct their own interpretations of their experiences within authentic work contexts. This approach to learning and teaching is known as the constructivist approach. According to this approach, each individual will have his\her own conceptualisation of reality (cognitive constructivism); however, these multiple realities must be shared with colleagues (social constructivism).

According to the constructivist approach, the role of instruction is not to enable students to learn predefined isolated skills but rather to guide them to tackle problems as experts do. This feature of the constructivist approach to

instruction is exemplified by several educational strategies among which is problem-based learning.

On the other hand, the cognitive approach treats learning as an internal process that involves memory, thinking, reflection, abstraction, motivation, and meta-cognition. It looks at learning from an information processing point of view, where the student uses different types of memory during learning. It also recognises individual differences in such traits as learning and cognitive styles, and suggests a variety of learning strategies to accommodate these differences. Ertmer and Newby (1993) indicated that the cognitive approach is most appropriate for complex forms of learning that include reasoning, problem-solving, and information-processing. Rowntree (1994) refers to the instructional design based on this approach as tell-and-test approach that is useful for learning facts but not for learning complex skills.

The behaviourist approach on the other hand looks at overt behaviors that can be observed and measured as indicators of learning (Good & Brophy, 1990). The behaviorists points out the importance of providing the students with the intended outcome of their learning before they start the lesson, which will work as a checklist for the students to make sure that they have achieved the learning outcome.

Instructional designers would mix the behaviourist, cognitivist and constructivist approaches to provide students with effective learning experience. However, the constructivist approach is the most appropriate one for promoting complex skills. When these skills are targeted by designers, the cognitive and behaviourist approaches play secondary, but important roles. Using Rowntree's (1994) classification of instructional design models, the Commonwealth of Learning (2005) refers to instructional design models that are based on the constructivist approach by the term "reflective action guide". The authors also show how technology can be used in implementing the model. Since computer technology can be used to supporting learner's collaboration, this technology would be an essential tool for implementing the constructivist approach to instruction. Thus, it is important that research continues to examine use of the principles of the constructivist learning theories for effective learning with technology.

As is the case with advanced countries, a developing country such as UAE, should benefit from research about the use of the principles of the constructivist approach for effective learning with VDS in design-related courses, especially when the country lacks the skilled national workforce. Since its unification in 1971, the UAE had been largely depending upon the employment of the expatriate workforce in developing its infrastructure due to the lack of skilled national manpower. Lately, realising the need for its own nationals to take over and participate in its awakening, the UAE

decided that education will help in creating a generation that is capable of tackling future challenges and substituting foreign workers (UAE Yearbook, 2006). As the country is witnessing a boom in the construction field, education related to this field has also to be emphasised and improved to meet the market needs.

The researcher intends to study the relationship between self regulated learning (SRL) and effective learning of design in UAE architecture schools via the VDS. In preparation for this study, the researcher conducted an exploratory study at the Architecture School of the United Arab Emirates University (UAEU) to gain basic understanding of the extent to which teaching and learning are aligned with the constructivist learning theory. Another purpose was to investigate students' difficulties, approaches, attitudes, perceptions and motivation related to effective learning of design. Specifically, the researcher sought answers to the following questions:

What are the students' preferred learning methods?

To what extent are students learning methods consistent with teaching methods?

To what extent are students ready for using on-line collaboration as the main method for learning design?

To what extent are students ready to engage in learning on their own and from experience rather than lectures?

How do students feel about the level and depth of the use of visualisation in learning and teaching design?

Did the assessment practices affect students' learning methods?

Would students accept assessment methods that are aligned with the constructivist approaches?

Do students lean more toward intrinsic or extrinsic motivation?

Many researches have been conducted in the field of VDS that tested its suitability in design courses as a communication tool (see Maher et al, 2005 and Kvan et al, 2000; Tokman 2007). The researcher could not find any empirical research that is conducted to highlight VDS effectiveness in the light of the learning theories. In general, the use of technology in education has been led by technology rather than by pedagogy, and this is true of the special case of the use of VDS in architecture education.

Many definitions for VDS found to be in existence in the literature see (Maher, 2001, Maher et al, 1999). Yet, for the purpose of this work VDS can be defined as a networked design studio that is assumed to enhance the performance of the Architecture students in their learning of construction-related subjects related to design synchronously (instantly) of asynchronously (delayed respond). VDS can be combined with the constructivist approach to promote effective learning.

TABLE 1. Relevance of VDS tools to the constructivism theory

	Learning Mode					
Technology Medium	from Each other	From Tutor	From Experts	Critique	Real Context	Comments
Forum	✔	✔				constructivist's theory social learning
Video Conferencing	✔	✔				Social learning-immediate feedback
Whiteboard	✔	✔		✔		Social constructivism
CAD	✔	✔		✔	✔	Social learning-design critique
3D Modeling					✔	
E-mail	✔	✔	✔			Social learning
News Groups	✔	✔	✔			Social learning
Animation					✔	
Instant Messaging	✔	✔				Social learning-immediate feedback

Based on the review of the literature, the author identified the most important technologies and tools that are common to VDS implementations as well as some pedagogical techniques. These are shown in table 1 and 2. The tables also show the relevance of these technologies and pedagogical techniques to the constructivist approach.

Table 1 identifies mode of learning using VDS technology such as students learning from each other, learning from tutor and learning from experts which is consistence with the constructivist theory's social learning. It also identifies learning from social context which represents one of the tenants of the constructivist theory. Table 1 shows the technology that matches each characteristic.

TABLE 2. Relevance of VDS pedagogical techniques to the constructivism theory.

Pedagogical Issue	Learning Mode					
	From Each Other	From Tutor	From Experts	Critique	Real Context /Problem	Comments
Project-Based Learning					✔	Match constructivist's core principle.
Problem-Based Learning					✔	Match constructivist's core principle.
Group Discussion	✔	✔		✔		Social constructivism
Critical Thinking	✔	✔		✔	✔	Working with peers from other universities, share projects and critique projects carried out by other groups.
Integration of Multi-Disciplinary Participant					✔	Work with other peers in the same university each carry different task, stimulates real life projects, help to improve teamwork skills
Simulated Real-World Imitation	✔	✔			✔	Learn from simulations of real world problems.

The above tables summarises the most common tools and pedagogical methods for a VDS environment where technology is used to enhance student's performance in design courses. The tables also show the match of each tool and method with the principles of the constructivist theory.

Study of specific individual student factors that influence effective learning with technology can contribute to advances in the theory of learning with technology. This is especially true when these factors have been shown to be relevant to effective classroom learning. The importance of the use of IT in enhancing student learning is well documented. In the academic arena, a number of researchers have addressed the issue of which student factors determine the success of its utilisation in the western countries (Toole, 2001). Though these studies did relate this utilisation to the learning theories, however, not enough such studies have been conducted in UAE. In particular, studies about use of the VDS in architectural schools have not been attempted in UAE. Cultural, social and economic conditions of UAE are similar to those of the Arab Gulf states. It would thus seem possible that the findings of research in UAE will apply to other Arab Gulf states.

Research has revealed that active learning is related to important student characteristics, such as the construct of academic self regulated learning (SRL). SRL has been shown to be basic to lifelong learning. More importantly, instructional practices can be employed to enhance SRL. SRL refers to the learning characteristics of students who actively take control of their own learning. Garrison (2005) asserts that SRL is one of three concepts "that help define and shape effective higher-order learning" in asynchronous online learning. In fact, the other two concepts (reflective thinking and metacognition) are dimensions of SRL. According to Zimmerman (1989) and Zimmerman and Matinez-Pons (1988), academic self-regulation reflects the extent to which students are metacognitively, motivationally, and behaviourally active in their learning. The importance of SRL stems from the contention that it explains transformation of mental abilities into academic skills and indicates the acquisition of skills that are necessary for lifelong learning (Zimmerman 2002).

The following sections will present the methodology followed in this study, followed by results of the study and a discussion of these results.

2. Method

The focus group methodology was used to identify students' perspectives of the current teaching and learning practices in the design courses offered in the architecture school of the UAEU. The aim of this investigation was first to gain a preliminary understanding of the difficulties, approaches, attitudes, perceptions, and motivation related to the learning of design in architecture schools. Second, the investigation was designed to assess the extent to which the students would be interested in the use of sophisticated technology in the teaching and learning environment in the UAE architecture education schools in order to achieve effective learning. The study was conducted in the UAEU because it is the largest university in UAE, and because other universities that house an architectural school or department follow a similar educational system. In addition to the focus group interviews with the UAEU students, unstructured individual interviews with lecturers from this university and the American University of Sharjah (AUS) were carried out. The purpose of the interviews was merely to validate the information collected from the students. For this reason, the interviews took the form of casual conversations whenever the researcher found an opportunity to talk to a lecturer in the UAEU after one of the focus group sessions. As for AUS lecturers, interviews took place after all focus group sessions were completed. AUS lecturers were interviewed to ascertain that the learning environment in this university was not too different from that of the UAEU. Though the lectures' interviews were unstructured, data gathered from these

interviews were treated with the same care as data obtained from the focus group sessions.

2.1 PARTICIPANTS

Participants were 60 students from the architecture school of UAEU, nine lecturers from the architecture school of UAEU, and four lecturers from the architecture school of AUS. A random sample of twelve students was drawn from the class list of each of the five cohorts in the architecture school. An equal number of students were selected from each of the male and female campuses. The college records indicated that the age of the students in the sample ranged from 19 to 25 years.

A preliminary meeting was held with each of the male and female students separately. In this meeting, the researcher informed the students of the purpose of her research and told them that she needs to collect information about their perceptions of the teaching and learning practices in the design courses. She, then, explained the procedure that will be followed and the time they need to devote to this work. The researcher also assured them that the collected information will be confidential and participation is voluntary. Small pieces of paper were then distributed in which each student wrote his/her name and indicated whether he/she was willing to participate. Only one male student from the first year cohort and one female from the third year cohort indicated they were not willing to participate. Both of them indicated that they could not devote the time needed because of personal reasons. The two students were replaced with randomly selected colleagues.

2.3 PROCEDURES

This work assessed the extent to which the constructivist and cognitive theories were implemented in teaching design courses in the Architecture schools of the UAE. To judge the congruence between these theories and teaching of the design courses in UAEU, it would be useful to describe the teaching methods of these courses. The following methods of teaching were found to be in existence in the UAEU Architecture School:

2.3.1 Studio Method

The studio method of teaching, with supplement lectures and practical work running parallel to studio work, has been accepted as the backbone in the architectural education. This approach to architectural education is successful mainly because of personal involvement of the student and the lecturer who is the best motivating factor in education. In addition, Nicol and Pilling (2000) referred to studio as real life experience condensed into a manageable amount of time and space. This method is practiced in the

UAEU in its traditional form which is referred to by researchers as the physical studio. The visualisation tools available for student include AutoCAD, Formz, StudioMAX and ArchiCAD. There are also a digitiser and a plotter. No VDS were found to be practiced.

2.3.2 Lecture Method

Formal lectures are used to define the basic areas of study, principles and theory. Lectures are given to students in a traditional lecture room setting with a normal class size of about 20 students. Visual aids are used when available and the PowerPoint presentation is the most popular apparatus for presenting both diagrams and notes.

2.3.3 Practical Laboratory Method

The practical laboratory method is used together with the lecture method to explore practical applications to some of the basic principles of the lectures, for instance, the laboratory test on the strength of building materials, or the person-environment relationship.

2.3.4 Site Experience

Experience about the project method has proven to be very useful and should be encouraged in architectural education especially towards the understanding of technical subjects such as construction technology. The advantages are numerous. For example, it helps the students understand the subject better by observing and experiencing the actual project being carried out. Another plus point for the students is they have the opportunity to appreciate the art and craftsmanship of building. The main drawback of this method is that it is very expensive and time consuming.

Prior to the focus group meetings, the researcher prepared an interview guide the questions of which flowed from the general to the specific. However, this guide was not intended to be faithfully followed. The researcher decided to refrain from interfering if the general question was sufficient to lead the students to cover all the aspects of the information needed. The questions were meant to be used as triggers when needed, and to turn the students back to the issues under consideration when the conversation strays away from these issues. The researcher also decided from the outset that she will allow the conversation to flow naturally by encouraging students to tell stories, and by ignoring student's tendencies in such situations to go back to an issue, interrupt each other, or even contradict themselves. This plan was necessary to strike a balance between the need to preserve the natural features of conversation and the need to keep the discussion focused without exceeding the limit of two hours in any session. This time limit was imposed to make sure that students will not lose motivation to discuss the issues proposed. In addition, the study was carried

outside students schedule times and it was necessary to ensure that the students will not be loaded.

The investigation was carried out in ten sessions. In each session, the participants were a group of students from the same cohort and gender. Homogeneity of the group members was necessary to ensure that younger students would not censor their ideas in the presence of older students. As male and female students in the UAE University attend their classes in separate campuses, it was necessary to organise separate meetings for the male and female students in observance of the traditions of the UAE community.

In the group sessions, the researcher faced two contradictory situations in the younger and older students groups. It was very easy to get male and female students in levels three to five to open up and work together in a social atmosphere to the extent that it was relatively difficult to get the students back to the issues under consideration. Moreover, male students in these groups showed no objection to the researcher's suggestion to audio tape the sessions. However, this was not true for the female students in levels three to five. Unlike the case of male and female students of level three to five, the researcher had to make some effort to get students in levels one and two to open up. In addition, when the researcher suggested to audio tape the session students felt uneasy. This was apparent from the silence that prevailed and the looks exchanged between the students. To ensure credibility of the collected information, the researcher made extensive written notes of the discussions of all female sessions and of levels one and two male sessions. As for the lecturers, the researcher made written notes of all interviews since these interviews were short. All audio taped sessions were transcribed. The written notes were reviewed immediately after each session to ensure completeness by adding notes recoded mentally.

2.3 DATA ANALYSIS

Qualitative data analysis of the transcribed students' notes proceeded in several steps. For each session, the notes were read several times. A search for preliminary themes was conducted in the first reading. These themes were recorded. In a second reading, discussions, stories, views, and ideas that were consistent with these themes were noted. At the same time, the researcher made effort to discover any additional themes that she missed in the first reading. The above procedure was repeated in the third and fourth readings of the notes. In three cases, a fifth reading was necessary. A further step taken was to compare the themes discovered in the various sessions. In general, it was considerably easier to discern the themes underlying level three to five data. In fact, the researcher found it easier to interpret the levels one and two data in the light of the themes discovered in the higher levels

data. The data collected from the lecturers was easy to interpret. In the following paragraphs, the findings from the exploratory interviews are presented.

3 Results

Three major issues persistently emerged during the focus group discussions: First, the differences between students' preferred methods of learning and teaching methods employed by the lecturers; second, the contribution of prior knowledge towards learning and understanding; and third, learning methods of students. These issues are discussed below

3.1 PREFERRED LEARNING METHODS

Three main problem areas came under constant discussion and were continuously referred to with regard to learning methods, learning preferences and motivation. These problems were brought up by both students and lecturers. Students' replays to the first three questions (see table 3) indicated that present methods of teaching are not positively contributing to understanding the subject of design.

TABLE 3 Question Guide

1	In general, how comfortable are you with the teaching practices?
2	In general, how do the available technological tools facilitates (did facilitate) your learning in the design courses?
3	Which technological tools are most effective in helping you to learn?

It was found from the interviews and discussions that effective learning on the part of the students can be improved by using the following methods:
Interactive and Simulated Real World Imitation: Students seemed to be critical of the lecture method, the current method of teaching. They have difficulty learning through just one sense, the sense of hearing. It was found that most students favoured learning through real time imitation. They believed they can understand better through imitating real life projects characterised by a design process involving a full team working together in one project. When one of the fourth level students offered a summary of the discussion about the topic by saying "it offers us the experience which we cannot get from reading books", the other students in the group expressed an overwhelming approval. This view was expressed more clearly by older than by younger students. One can conclude that the older students believed that collaboration helps them in appreciating and understanding the subject much

better. Younger students did not express this idea with such clarity. Quite a number of times younger students mentioned that they normally seek advice or discuss design problems with their friends or seniors. They indicated that they felt more comfortable and achieved better understanding when they discussed design problems with their peers.

Hands-on experience: Students in the third to fifth levels agreed that the models which they built were simple and unsophisticated at the beginning, but with experience, support, and reflection, they became increasingly complex. On the basis of this, they argued that the tutors' role should not be to do the job on their behalf, but rather to facilitate learning. They clearly indicated that tutors should not only communicate the important facts and concepts in the discipline but also, and more importantly, help in bridging the gap between the structures of the discipline and the structures in their minds.

Visualisation: Students in all levels emphasised that they can understand and communicate in the design process better when visual aids are used. In question seven (see table 4) many of them commented on the current practice as being very superficial and lack of visuals and in-depth information.

TABLE 4 Question Guide

7	Which method would help you in understanding the principles of design? Being taught the principles in the class and giving you the chance to apply them in the lab or providing you with opportunities to discover these principles on your own?

11	Imagine that you are the head of the department, what changes would you make in the teaching and learning methods?

Students' attitudes towards learning were considerably influenced by the need to visualise three dimensional illustrations (3-D illustration) such as designing in 3D on the assembling of building components, axonometric drawings, exploded forms and videos on the problems and difficulties faced during the process of designing. In fact, perception towards three dimensional drawings were highly favoured by them and perceived as one of the best methods to better understand applications in design. The majority of the students pointed out that they would understand the subject much better with appropriate visual aids. Many of them were not satisfied with the present teaching methods.

3.2 STUDENTS' LEARNING METHODS

It was apparent that the main method of learning adopted by students was rote learning. However, it was found that students also used repetitive sketching, especially on detailing of various construction techniques so as to help them to pass in examinations. Focus on passing examinations and achieving good grades surfaced in relation to almost every issue discussed (see questions 8 and 9 table 5).

TABLE 5 Question Guide

8	To what extent does feedback on design assignments help you to make progress?
9	How is your work in design assessed?

12	Imagine that you are the head of the department, what changes would you make in the assessment approaches?

In many occasions, students seemed to contradict themselves. Examinations based on textbook materials and lectures seemed to be preferred. At the same time, teaching methods that promote higher-order thinking skills were preferred. Students advocated learning via collaboration in projects and discussions with experts. They highly regarded learning situations that would bring them in contact with professionals working in real life settings. They expressed desire for working on problems that require creativity and decision making. Yet, they preferred the safety of traditional methods of assessment. At times, they seemed to suspect the ability of the lecturers to assess their work via non-traditional evaluation methods. Additionally, students criticised the assessment of design projects which according to them, heavily emphasised the presentation aspect. To accommodate this, less effort was put into the process and teamwork. In the following statement, one student expressed regret towards remarks made by one of his lecturers: "In my opinion, the school emphasises too much on presentation (colour, drawings, etc.)"

3.4 ATTITUDES AND MOTIVATION

Despite heated discussions on students' learning problems; there was hardly any mention of their antipathy towards design (see table 6).

TABLE 6 Question Guide

4	When you are faced with a difficulty in a design assignment (project), who do you turn to for help?
5	How do you relate the principles you learn in the lecture to the design

	assignments or projects?
6	How do you evaluate the balance between the theory and practice in the design courses?

The students showed they were interested in the design projects that were assigned to them. There were no complains about the load of the work and the time that they had to spend on the projects. In fact, in many instances they indicated that the time they spend working on the projects was more enjoyable than the time they spent in the lectures. All students agreed that they were motivated to learn the subject but were faced with problems in understanding it, probably in relation to the design process. The most significant issue related to this problem was the underlying learning motivators towards this subject.

Discussions of students around this issue indicated that long term goals provided for the most effective motivation to learn design. Indicators of intrinsic motivation were apparent in students' discussion around this issue. During the discussions, many behavioural references to Vallerand et al.'s (1992) categories of intrinsic motivation were made. For example students indicated they felt great joy when they finished a project to their satisfaction. They also indicated that the joy they felt was not only when they finished their project but also as they were working on it. They felt that the stimulation they experienced as they worked drove them to keep working. In addition, students revealed that they felt satisfied when they succeeded in implementing design principles in their projects. Three other factors related to extrinsic motivation were highlighted during the discussions in almost all groups, namely: Lecturer's enthusiasm for the subject (dedicated lecturer); positive relationship between lecturers and students; and well organised system of communication and instruction.

4. Discussion and Conclusions

The results provided satisfactory information sought by the researcher. Students learning methods were, to a great extent, consistent with the teaching methods. It was clear that the assessment practices forced the students to adopt rote learning. However, there were obvious indications in the discussions that these learning methods were not what the students preferred. Results revealed that students prefer learning methods that utilise simulation or even real situations where they can interact with experts, collaborate with colleagues and learn from each other. For such learning methods to be effective, students need to show intrinsic motivation. Though students argued that they were more driven by intrinsic than extrinsic motivation, they admitted that the assessment practices forced them to fall

on rote learning. Thus, the extent to which intrinsic motivation prevails was not clear.

It was also clear that students were not satisfied with the level and depth of the use of visualisation in teaching and learning. It would thus seem that use of the VDS for learning design will be welcomed by the students. To use the VDS for implementing the constructivist approach, students need to adopt collaborative projects as the main method of learning. They also need to accept assessment methods that are aligned with this approach. The researcher was not entirely successful in directing the discussions in such a way as to provide sufficient information about readiness of the students to engage in collaborative projects as the main method of learning. This was also true of readiness to accept assessment methods that are consistent with the constructivist approach. However, students did express views that were consistent with the cognitive and constructivist learning theories.

In summary, the learning and teaching problems in architecture design courses that surfaced in the focus groups discussions can be dealt with via the intermarriage of learning theories and the VDS technology. As indicated in the review of the literature, the constructivist approach emphasises collaboration and learning by doing to achieve construction of meaning and transfer. The tools provided within a VDS platform can facilitate the implementation of these approaches. The group discussions indicated that students, in general, were ready to adopt the social constructivist approach to learning the design subjects. Their enthusiasm for both collaborative learning and visualisation indicated that effective learning via the VDS would be acceptable to them. However, showing indicators of acceptance of effective learning with the VDS does not necessarily mean that this teaching and learning approach would be effective. This is especially true in view of students' rather vague reactions to non-traditional approaches to assessment. It would thus seem that the effectiveness of using the VDS would depend on students' individual characteristics such as SRL characteristics. In view of this, it can be concluded that students with higher SRL characteristics would benefit more from teaching and learning methods that are based on combining the VDS with the constructivist approach.

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