Assessing Creativity: A Test for Drawing Production using Digital Art Tools

The concept, application and assessment of digital art teaching as a means of enhancing creative proficiency

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Abstract—**This paper describes the Test for Creative Thinking - Drawing Production (TCT-DP), including its design, concept and mode of assessment, and the practical consequences of its application in a specific context. The test was used to evaluate the performance of groups of students as part of a case study exploring the use of digital art tools for drawing in a junior school. The students used specific digital art software via both computers and tablets, and also drew manually using a variety of devices. TCP-DP evaluates drawing production by means of a set of 14 criteria. At the same time, this study used the Technology Acceptance Model (TAM) theory to assess the ease of use and usefulness of the digital tools. The test was trialled with students aged 9-10 years in different ability groups. There were no significant differences in performance between male and female participants. Details of various related studies, together with data concerning the reliability and validity of the TCT-DP test, are also provided. The study finds that motivation is an important factor in improving young people's artistic ability.**

Keywords - Digital art tools; artistic ability; assessment of digital artwork; assessment of digital tools

I.   INTRODUCTION

When considering the adoption of a technological approach to art, it can be argued that creative individuals should be able to develop their intellect through digital drawing activities, along with the development of their imagination. It can also be said that the visual image could become a means of diagnosing intellectual development. The research discussed here found that digital technology certainly helped to improve children's artistic ability and enhanced their creative activity.

Some previous research has suggested that the production of art through computational technology may lessen creativity. For example, Lanier discovered that technology can lead participants to accept the lowest common denominator [1]. Another researcher, Pinsky, found that work attempted through computer-based routes was "too sanitized" and did not have the "human touch" [2]. However, although some have opposed the use of computer technology in learning for young children, Cordes and Miller argue that the outcomes for youngsters' development as a result of the use of technology in educational settings have been widely documented and illustrate positive feedback [3]. For example, children who use PCs have been found to show several benefits in their intellectual development and constructive knowledge, as well as in their problem solving and language abilities, in comparison with those who do not apply technology in their learning. Thus, it seems clear that the use of technology in educational environments has shown highly beneficial results.

The effects have also proved to be positive in the area of art and creativity. Matthews and Seow did a study of 12 children, aged from 2 to–11 years, using electronic paint on tablet computers [4]. The observers videotaped children drawing with both tablet computers and traditional media (pencil, markers, paint and paper) in normal surroundings. Similarities were discovered in the children's work using both sorts of media tools, but it was also discovered that stylus-interfaced technology offered a unique tool for drawing when contrasted with the findings of earlier work conducted by Matthews et al. [5], which utilized mouse-driven electronic paint only. Tzafestas also provides an example of working with both digital and traditional tools, and using special software in the laboratory of Athens Technical University [6]. This involved an attempt to integrate traditional methods with digital drawing and painting by developing a tool called an 'Ant Brush'. It was found that digital drawing tools could add additional factors in terms of colour and line to the user's design. In fact, the drawing tool possessed a limited degree of autonomy. This factor proved to be helpful in improving and motivating the students' work, and in giving the children more confidence. Additionally, Arrowhead et al. [7] found that using computers improved the motivation of elementary children in the writing process [7], whilst another researcher, Katsiaficas, demonstrates that digital tools can motivate and build artistic creativity, as well as being easy to use, particularly in circumstances when flexibility is needed with regard to source materials and techniques [8]. Haugand further adds that the provision of images and sounds to support pupils' natural engagement in the creative process is directly concurrent to motivation [9].

This study intended to investigate whether digital tools could help children to express their ideas through drawing. It aimed to explore whether there is optimal methods that can be used to both strengthen technical skill and develop artistic imagination, and to consider how artistic creativity can be

assessed. The study involved the observation and interviewing of students in a primary school, in order to evaluate how students interacted with both digital and traditional tools.

The remaining sections of the paper are structured as follows. Section II presents the methodology used to test students in primary school in their use of digital art tools. Section III describes how the study used different approaches to gain an accurate assessment by using both the psychomotor domain taxonomy theory and Technology Acceptance Model (TAM) theory. Section IV presents the new model created to summarize the results derived through both the theories mentioned, and Section V provides examples of the outcomes achieved using the 14 criteria of TCT-DP. Section VI suggests how these 14 criteria may be used for assessing artwork, while Section VII discusses how the students became more skilful in their use of the digital tools. Section VIII evaluates the primary results and finally, Section IX provides a conclusion.

II. METHODOLOGY

The study population comprised a group of about 25 students within the age range of 9-10 years old in a primary school. The case study was conducted in the UK and tested the use of digital art tools in an ICT room. It was carried out using a drawing project finalized in collaboration with the school, which took 12 weeks. Although the project was limited in terms of size, time and setting, it did allow an in-depth study. The entire research actually involves two case studies, and while the first study has been done, the second study is still in progress. Comparison between the two cases will enable the research to present accurate results.

In the first study, the students were tested in their use of both traditional and digital tools, and the observer attempted to be as non-subjective as possible. The researcher observed the pupils' activity, took notes and recorded how the pupils dealt with the technology, as well as noting which tools were easy to use and useful. The students used two forms of art software, which were Sketchpad (see Figure 7) and Art Rage (see Figure 6). The first was utilized via PC and the second via tablet.

The idea chosen by the observer was to create a link between an ancient civilization and modern life by using a single project to combine ideas. This would allow the students to think intensely and use their creative imagination effectively. The students first used various traditional tools such as pencil, eraser, sharpener, colours and drawing paper. After this task, they worked on the same idea using digital tools via PC and tablet, but this time applying only drawing and painting tools.

A teacher assisted the students with their work. In noting how the children dealt with the technology, and which tools were easy to use, the observer considered a number of questions. For example, are the pupils using the tools correctly to complete the artwork? Do the tools appear to encourage creative self-expression? What is the motivation behind the pupils' use of some tools more than others? Is it because they are easy to use or because of their usefulness? Do the various tools stimulate and motivate children to produce creative pieces of artwork? The children's motivation was assessed via questionnaire before the test, along with an interview after the test was completed. The usefulness of the tools can be assessed through the artwork produced, using clear assessment boundaries, as well as through continuity of activity and completion of work.

The teacher's method and skills can motivate the students to improve and build on their artistic ability. For example, the teacher can ask the student to use different tools in order to explore the function of each. The results gained from observation, interviews and questionnaire suggest that the majority of pupils (approximately 90%) felt that using digital tools increased their artistic skills. They also felt that having pictures in the art room enhanced their creativity and that their computer skills had improved. In addition, a significant majority, particularly among the boys, felt that the tools provided a lot of motivation to improve their art work. The primary results of observation show that about 60% struggled with the 'Save Picture', 'Select' and 'Lines' functions, the latter being the hardest tool of all. About 80% of student struggled with this, so pupils preferred to ignore it rather than learn how to use it. Varying numbers of pupils found the tools difficult to access and remember. All students found the computer useful, with very many finding its tools adequate, but some found the tablet the most useful. 80% of students found that they could not control some tools such as pencil or black felt. The reason for this may be that all the tools are controlled by mouse, and the mouse cannot always be as flexible and adjustable as the human hand for controlling tools.

The teacher first asked the pupils to work separately, and to draw a simple sketch by pencil and paper. Each of them did this using their own imagination. After they had finished their work, the teacher asked two or three students to combine their ideas into one artwork using digital tools. Upon completion, the observer noticed how the project had changed from a simple idea to a complex, more creative one. Specific tools helped the pupils to be creative, such as tools for Designing, Stamp and Text, Magic and the Colour tools.
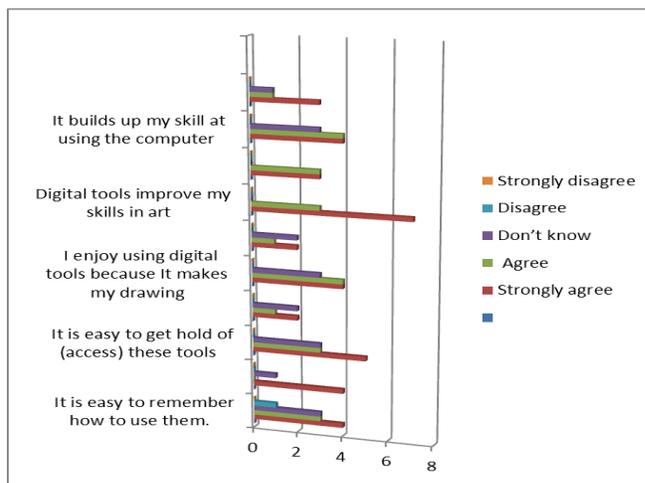

Figure 1. Summary of information from questionnaire regarding pupils' use of digital tools.

Figure 1 shows the results of the questionnaires and how students interacted with the digital tools. The majority of both male and female participants said that they liked to use technology, but a higher number of males than females said they preferred to use digital tools. PC software was the most favoured digital technology, which was preferred by 90% of the students and was more popular than the tablet and iPad art tools. The pupils said this was because they use computers more than other devices in school and also at home. Although half of the group that owned iPads/tablets found them enjoyable for artwork, 90% found that traditional tools were more effective than these digital tools.

The research can be regarded as valid and reliable because the researcher recorded and took pictures of the students working in the ICT room, as illustrated in Figure 2. Furthermore, other researchers in this field have used similar methods with young students. For example, Couse et al. [10] examined the viability of tablet computers as a medium for digital artwork with children; in particular, they explored how easily the children adapted to using them for drawing over a six week study in a classroom setting. Both quantitative and qualitative data was obtained. Ortegren (2012) also conducted a study on the subject of art in conjugation with digital media, and investigated how pupils perceived certain aspects of teaching and work methods. Ortegren's case study focused on pupils of 7-9 years old [11], and also showed the benefits of digital image media along with multivoiced teaching. Tanir, et al. [12] conducted a further study over 14 weeks with an experimental group. Implemented within the undergraduate programme of a primary school teaching department, the study suggested that learning through visual arts was an effective method for primary school teaching.
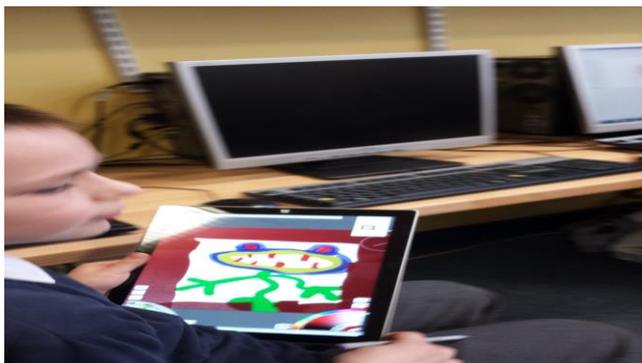

Figure 2. Students working in ICT room using digital art tools for drawing.

III. THE ASSESSMENT OF TOOLS AND THE PSYCHOMOTOR DOMAIN

It would seem that an equal preference for both qualitative and quantitative methods can be observed in previous research, with case studies, questionnaires and observations being the most important methods for research with young children. In addition, in a study such as that described here, the researcher should be dedicated to helping children use

different approaches and equipment, and to encouraging them to express their opinions, ideas and preferences. It is important to "listen to what the children are saying; to be non-judgmental and let children ask their questions" [13]. Children have different ways of expressing themselves and therefore, different methods are needed to capture this expression. It has been found that the mixed method approach "gives importance to the children's actions and the contexts in which they occur" [14].

As well as considering the pupils' perceptions, this research attempted to test two theories in the art classroom, one of which was the psychomotor domain taxonomy model [15]. The psychomotor domain relates to skills that require the use of the muscles of the body which may be measured according to Bloom's Taxonomy [15]. These include sports skills, writing skills and drawing skills. The theory describes several stages involved in learning these skills. As the psychomotor domain taxonomy can be used to evaluate the development of pupil's skills, it can be appropriately applied to young children who are learning art and gaining creativity. The theory was used with students studying art and visual media in an ICT room, in order to determine whether the use of digital tools for drawing can help students to learn in specific stages as they improve their artistic ability and develop technological skill.
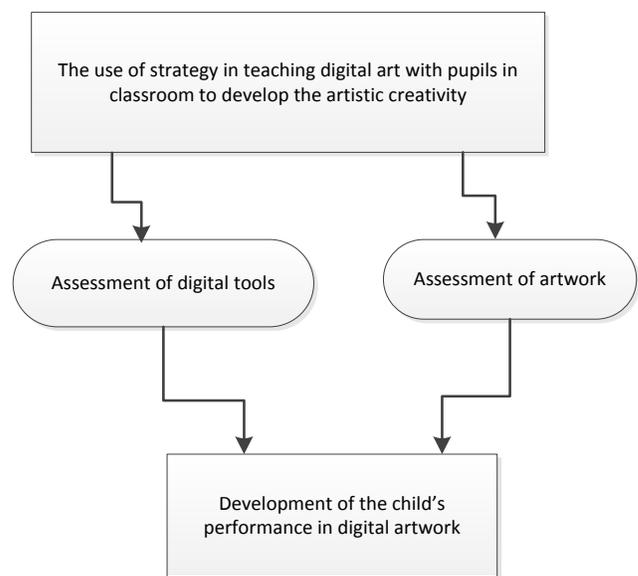

Figure 3. The process of measuring improvement in pupils' achievement.

The present research concentrates on the stages involved in acquiring drawing skills, and how children improve over these stages. This domain was tested in relation to pupils' drawing in class using digital tools. The students were tested on their response to a new topic they had not tried before, which had been chosen by the observer. When the principle of psychomotor domain taxonomy was applied, the test showed how students quickly learned new skills appropriate to their age. The aim was to investigate how pupils would improve their performance in drawing using digital tools, and how they would respond visually to a project involving a new idea. More details about the psychomotor domain

taxonomy model in relation to children studying art and visual media can be found in [16].

This model was then linked to a modified version of the Technology Acceptance Model (TAM) [17], which is used to assess the ease of use and usefulness of digital tools. The TAM model is an information systems theory that shows how users come to accept and use a particular technology. The child's motivation to create good artwork enhances the desire to use digital drawing tools perfectly and to improve their performance. This gives the result that when a pupil understands how to use the digital tools, and has learned which are easy and which are difficult to use, the child will grasp the usefulness of particular digital tools. Perceived ease of use (PEOU) refers to the degree to which a person believes that using a particular system would involve making an effort [17]. Perceived usefulness and perceived ease of use can be considered cognitive factors.

The present study suggests that both theories, modified TAM model [18] and the psychomotor domain taxonomy, [19] can work in parallel to assess how students use digital art tools. Both factors can contribute to assessing students' artwork, in order to determine the extent to which digital tools help students both artistically and technically. Figure 3 illustrates the process of measuring improvement in pupils' achievement.

IV. NEW MODEL FOR THE ASSESSMENT OF CREATIVITY IN ART WORK

In order to summarize the results of the research and to test the theories mentioned, it was necessary to modify the TAM model for use with children in the field of digital assessment. It is very difficult for young people to assess ease of use and usefulness based purely on their own knowledge, because they still

have a lack of experience. Therefore, the researcher created an assessment model based on observation, interviews and a questionnaire. Figure 4 shows the features of a child's creative levels in association with surrounding factors such as culture, background, financial situation, opportunities and psychological factors. If all these subjective norms in a child's personality are considered, this can help the teacher to motivate young students to explore the ease of use and usefulness of tools, because the more the child learns, the more motivated he/she will become by new ideas. This can provide greater incentive to learn how to use new tools effectively. This in turn will allow them to achieve technical skill, to improve artistic ability and enable them to have sufficient understanding to evaluate the tools.

However, this method of evaluation is not sufficient to assess the benefits of the tools in terms of their effect on the students' creativity. Therefore it was necessary to find an effective method of assessing and evaluating artwork, and one such method is "The Test for Creative Thinking - Drawing Production" (TCT-DP). This concept uses a set of 14 criteria to assess artistic creativity [19]. It was designed to evaluate artwork produced by traditional methods, but this study intended to use these same criteria to test visual art work produced using digital tools.
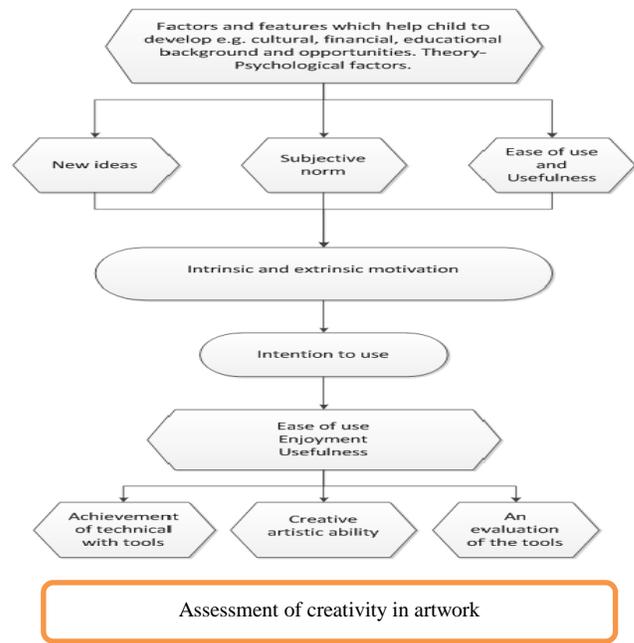

Figure 4. New prototype based on Modified TAM Model

V. EXAMPLES OF CRITERIA

Before attempting to measure the creative use of digital tools, it is important to consider what is meant by creativity and why it is important in education. There are many definitions. Traditionally, only very talented people were called 'creative', such as da Vinci, Einstein, Darwin, Shakespeare and others. More recently, it has been widely accepted that all individuals can be creative, and creativity does not occur only in the traditional arts and sciences. Creativity is regarded as an essential skill for any individual and for society. The National Advisory Committee on Creative and Cultural Education (NACCE), established in 1999, offers a definition of creativity which is useful for education, describing it as "imaginative activity fashioned so as to produce outcomes". This definition is useful because it includes five characteristics of creativity: using imagination; a shaping process; having and achieving purpose; being original; and judging value. All these things, successfully taught, can result in work that has value to others, as well as helping the individual who produces the work to develop a type of mental activity that may be described as "possibility of thinking" [20].

In order to assess artistic creativity, however, certain criteria must be used. With regard to assessment of traditional art work, the conceptual deliberations of experts led to the development of a set of 14 key criteria which, as a whole, constitute the TCT-DP construct. In this study, these 14 criteria were used to assess the digital artwork, along with the tools already mentioned.

A. Assessment of Drawing Production (TCT-DP) as used in this study

Davis summarizes in his review of TCT-DP that it is "…a new, carefully developed, and possibly useful creativity test. Some researchers are impressed with its

potential for identifying creatively gifted children [21]. It is difficult to assess whether it will do more than existing American creativity tests. Efficiency of administration and scoring is a definite plus". In addition, Cropley's (1996) review maintains that "The TCT-DP is a major addition to the battery of creativity tests. It offers an approach to creativity tests that goes beyond the divergent-convergent thinking distinction [22]. It also goes some way towards incorporating non-cognitive aspects into measurement of creativity". Davis adds that "The procedure itself is interesting for the people being tested as well as for those scoring the test. The manual reviewed here is highly readable, and is also thorough, in providing not only practical instructions but also convincing theoretical and technical material justifying use of the test by both researchers and practitioners" (p.227). The test author totally agrees with Davis' final statement, that "As with limitations that plague all creativity tests, the TCT-DP should be used in conjunction with other information (e.g., another creativity test, or teachers' or parents' ratings) in order to minimize false negatives - missing creative children whose variety of creativity is different than that measured by a single test" (p.91).

The present research used the design, concept and evaluation scheme of TCT-DP, as described by previous experiences and results of its application [20]. The adoption of this approach was designed to reflect a more holistic concept of visual media, as it was used to evaluate proficiency in the use of digital art tools. More specifically, it was used to assess the ability of children of primary age to use such tools to produce creative artwork.

VI. NEW APPLICATION OF TCT-DP

The current study suggested that the application of these 14 criteria could be used to help assess artwork created using digital tools (see Figure 5), in order to investigate whether the tools could contribute to and strengthen children's artwork. This application could be used in the art classroom to evaluate enhancement of students' artistic ability and imaginative development. Two sides of the application would be required, one side for teaching and a second side for students. Each student would have their own storage area where they could save all their work.

All the applications would be linked to the internet, to enable the students to send their art work to the teacher via email, and to allow the teacher to give the students feedback and scores, again by email. Students would not be able to see each other's work or feedback. The teacher would have a list of criteria showing clearly what tools students had used in their work and which they had not, because this record of tools used would enable the teacher to assess any creative enhancement in students' work correctly. In addition, the students would know from the feedback where they had made mistakes.
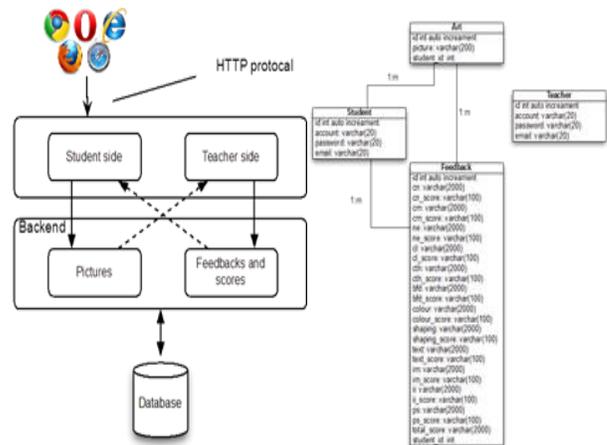

Figure 5. Application tested to ascertain its effectiveness in assessing pupils' artwork with digital tools.

This application was tested to determine whether students' artwork could be assessed, whilst at the same time evaluating the creative enhancement of their work using digital tools and the suitability of the tools for their age range.

VII. DISCUSSION

The main aim of the case study was to investigate whether digital art tools were able to motivate the children to improve their artistic ability, express their imagination and develop their technical skill. It appears that digital drawing tools can help to improve artistic creativity in children by providing ways of trying out new ideas, and new ways of thinking and problem solving. The research found that the concepts and digital tools complemented each other. The more the students used and worked with the tools, the more they were able to progress their ideas. As they became skilful at utilizing the tools, they were motivated to produce good work and learned how to be creative with them. The teacher's role is very important in stimulating students to use the tools correctly, encouraging them to apply the appropriate tools for each step, and motivating them by assessing their artwork. By the end of the project, the students had learned how to evaluate the tools correctly, after correcting mistakes many times and sometimes using inappropriate tools before finding ones that worked more effectively. The observer noted how the children's approach changed during the sessions. For example, when the students started working, their thinking was simple and realistic. Later they changed from naturalism to more abstract ideas because their thinking had improved since they learned how to use the digital tools. The students also learned from each other, especially when they were encouraged by their parents, family, the environment and the school.
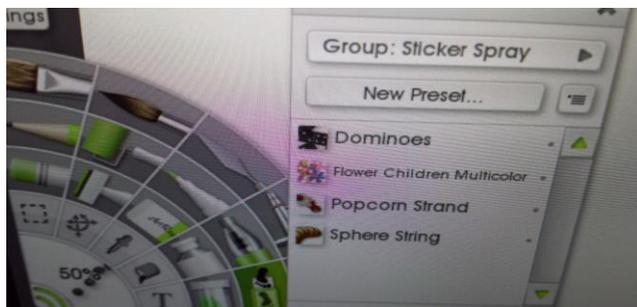
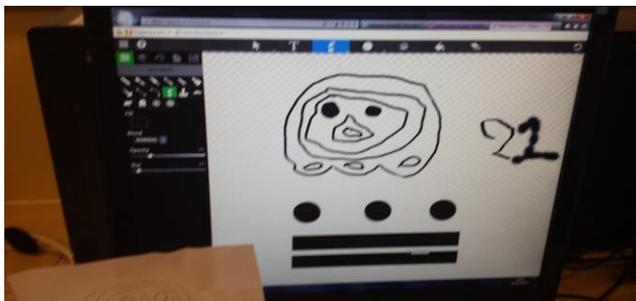Figure 6. Students drawing with Art Rage software using a tablet.

Figure 7. Students drawing with Sketchpad software using a computer.

The research found that motivation is an essential factor in the progress of the student, as is interaction between them, for example, to give the student new ideas they had not used before. Sometimes they repeated the same work at home, creating competition among the students. All these factors helped to motivate them to interact with the tools. It can therefore be said that the research produced successful results.

VIII. EVALUATION

The researcher found that it is important to explore a range of strategies and methods of teaching art, not just because art is a practical and technical subject, but also because it is different from any other school subjects. Although the outcome was successful, it must be accepted that not everyone is interested in working with digital tools, or in creating art by digital means only. Another observation was that many of the students struggled to understand the distinction between ease of use and usefulness. They could grasp the meaning of ease of use, but not the concept of usefulness.

However, it was interesting to note that, in general, ease of use was not the main motivation when the children used digital tools. They found more ease and enjoyment, generally, when using traditional methods. The most popular digital methods were sometimes the easiest to use, but according to their own statements, it was not the ease of use, but the successful effects the tools provided, which motivated the children to use them. It seems, therefore that enjoyment and artistic satisfaction counts more, to the pupils, than ease of use. Thus, usefulness is more valuable than easiness.

IX. CONCLUSION

Based on the information from observation, interview and questionnaire, it can be said that the children worked well and felt that the digital tools had improved their creative ability. They were quite strongly motivated to use them by a wish to create good artwork, and also by the drive to improve their technological skills. There was also some understanding of the value of these tools in learning other subjects.

It seems that, in general, ease of use was not the main motivation when the children used digital tools. They found more ease and enjoyment, generally, when using digital and traditional methods. The most popular digital methods were sometimes the easiest to use, but according to their own statements, it was not the ease of use, but the successful effects, the tools provided, which motivate the children to use them. It seems, therefore that enjoyment and artistic satisfaction counts more, to the pupils, than ease of use; the usefulness is more valuable than easiness. Also, the motivation is important for young students to enhance their artistic ability and improve their creative activity. The modification TAM model showed itself to be very useful in assessing the value of traditional and digital tools.

Psychomotor domain taxonomy was also useful according to the children's progress in learning to use digital software. It helped in noting and assessing the students' progress generally. The Test for Creative Thinking - Drawing Production (TCT-DP) is still under testing. We hope this test will help us gain more results in assessing digital artwork. In our opinion, the digital tools did improve the children' artistic expression and creativity.

This study is still in progress and will be completed soon. These are only the primary results from the sample test. The final outcome will enable a more detailed consideration of the effectiveness of the TCT-DP application in assessing the pupils' artwork. This will in turn enable a fuller evaluation of the extent to which digital tools can enhance students' creative proficiency.

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