A Novel Mobile-based Assessment Application for Evaluating Students' Creative Artworks in Higher Education

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ABSTRACT
Over the years, the human evaluation of students' creative artwork has been a thorny issue in creativity research, as the value of student's creative artwork varies from one art expert to another. Therefore, it was necessary, in the digital age, to employ modern technologies to limit human interference in assessing creative artworks of students in a way achieves objectivity, credibility and also maintains the creative and innovative aspect of the artwork.

This paper proposes a semi-automated mobile App for assessing students' creative artworks in Egyptian institutions of higher education. The proposed mobile-based artworks assessment app integrates the content analysis approach and views of art experts. The content analysis approach is used to calculate the affinity scores of the student's artistic design with the desired art model and represents 70 percent of the total course score. The art expert opinions are used to calculate the creativity of the student's artistic design and represents 30 percent of the total course score.

In two planned stages, the process of evaluating the performance of the proposed mobile-based artworks assessment App was performed. In the first stage, the usability of the proposed mobile-based artworks assessment App was tested, and the findings of this stage were very satisfactory.On other hand, in the second stage, the accuracy of the proposed mobile-based artworks assessment App in assessing students' creative artworks was measured, and the outcomes of this stage revealed that the proposal App achieved an outstanding accuracy above our expectations, making it one of the first digital applications to assess students' art designs in an informed and fair manner.

General Terms
Higher Education Institutions, Creativity, Aesthetic Activities, Visual Arts, Art Criticism.

Keywords
Artworks Evaluation, Content Analysis, Art Experts, Semi-Automated Android Application, Validity Test, Accuracy Test.

1. INTRODUCTION
Emotions are the primary component of personality development and affect an individual's ability to adapt to the world and to new challenging situations [1]. One of the most important tools for expressing and stirring-up human emotions is artistic designs [2, 3, 4 , 5].

Art has always been a field that has received a lot of interest from various psychologists [6]. At the beginning of the past century, health psychologists demonstrated that the art can be employed to treat emotional shocks, improve awareness of self and others, develop the capacity for self-reflection, and provide new ways to change behaviors and thoughts [7]. At the end of that century, psychologists expressed another spiritual function of art, which is that art plays a prominent role in achieving human happiness [8].

In fact, classifying what could fall under the concept of art was a point of contention among philosophers, as some philosophers saw that anything that achieves entertainment is considered art [9], while others assert that art is a broad field that encompasses various activities, such as painting, poetry, dance, music, design arts like architecture, industrial, fashion design and crafts including pottery, stained glass setting, and rug weaving [10].

According to Damasio (1999) and Freud (1979), good education should employ art in knowing, developing, and controlling psychological orientations, psychological attitudes, personality traits of both children and adults alike[11].

In the university sector, teaching arts plays an essential role in educating different curricula, as it helps in developing the artistic sense of students, enhancing their creative skills and potential -whether moral, intellectual, aesthetic or physical-, which leads to the production of high-quality artwork and contributes to achieve the goals of high-quality comprehensive education [12].

Evaluation has become an integral part of educational process and is increasingly used for various purposes, such as measuring what students have learnt, promoting students and ensuring that they meet the required standards [13]. Unfortunately, evaluation of students' artworks is the most problematic issue and always presents a dilemma for the educators [14], because artwork can have different interpretations and meanings when observed by different artists [15] and the creative value of the artwork is influenced by the artist's culture and the society in which he was formed[16].

In literature, there are two aspects to understand and evaluate students' artworks. Aspect-1, is concerned with recognizing the visual elements of artwork - such as shapes, colors and textures -, and the ways in which these elements are usefully organized.Aspect-2, is concerned with the meaning expressed by the artwork exceed the visual elements and their relationships [17].

With the creation, development and speed of internet access, educational technical equipment took a big step forward, and

the efforts of engineering scientists focused on reducing the size of electronic devices in order to enable students and teachers to easily carry electronic devices and use them to access the information necessary to develop the educational process [18].

Today, the rapid advancement of cutting-edge mobile technology has stimulated developers to introduce a broad range of mobile apps that serve various institutions, whether financial, tourism, entertainment, ... etc [19].

In practice, these developments have gained great acceptance among the faculty members community due to the benefits provided by mobile learning including, knowledge sharing without restrictions on the level of time and space, developing critical thinking, enhancing participatory learning and promoting problem-solving and lifelong communication skills[20, 21].

This research paper presents the phases of development, implementation and testing a new mobile App for evaluating students' creative artworks in higher education institutions in Egypt.

The rest of the paper is divided into five sections, which are organized as follows: Section 2 presents the important relevant papers and the study background. Section 3 defines the study problem. Section 4 explains the proposed mobile App details. Section 5 discusses the experimental results.Finally, the last section sums up the study and suggests the future work.

2. THEORETICAL BACKGROUND

To better understanding the current study, we will firstly introduce some of the previous studies and we will secondly give a brief discussion on the content analysis approach, which is the backbone of the study. A detailed discussion of each of these two parts is presented below.

2.1 Relevance Studies

It was necessary to review some prior perspectives in the literature to set a cornerstone for this paper. A number of previous studies related to our research field will be displayed in chronological order from oldest to newest as follows:

1- A study entitled "Making judgements about students doing work: lecturers' assessment practices in art and design", which was conducted by "Orr, Susan, and Sue Bloxham.(2013)", and reviewed the assessment activities in two major categories in higher education institutions: art and design. The main objective of this study was to explore art and design activities as lived and experienced by the lecturers of art and design. This research relied on two groups of pre-existing studies. The first group tested the assessment through think aloud and observational methods. The second group highlighted the assessment of creative practice rather than the espoused assessment approaches adopted. The results of the study showed that, the lecturers used three comprehensive concepts of quality to assist the judgment operation, namely demonstrating important learning over the time, demonstrating efficient studentship and presenting valuable artwork [22].

2- A study entitled "An interactive peer-assessment criteria development approach to improving students' art design performance using handheld devices", which was conducted by "Lai, Chiu-Lin, and Gwo-Jen Hwang.(2015)", and presented a developed peer-assessment criteria based approach to help students in assessing peers through advanced standards, learning from peer work and understanding the processes performed while designing artwork using mobile devices. The evaluation of the proposed approach was performed on an art course in primary school on a sample of 130 students who were divided into two groups: an experimental group that learns through the proposed approach, and a control group that learns through the traditional peer assessment approach. The results of the study showed that, the proposed approach improved students' learning performance, learning motivation and metacognitive thought[23].

3- A study entitled "Evaluating students' performance in responding to art: the development and validation of an art criticism assessment rubric", conducted by "Tam, Cheung On.(2018)", and reviewed the development and validation of an art criticism assessment rubric (ACAR) for assessing students' written responses to artworks. In this study, eight evaluation criteria based on Feldman's and Geahigan's theories of art criticism were specified to examine the reliability of inter-rater (IRR) of the ACAR. The initial test of the IRR was performed and the IRR achieved an intra-class correlation coefficient (ICC) of 0.9, which was rated as excellent. In this study, six separated evaluators - who were spitted into three groups of two members - were trained and participated in the assessment of 87 art criticism essays written by students from eight high schools. The results of the study showed that, the ACAR acquired good scores of ICC in the majority of the evaluation aspects, making it an allowable rubric to provide a reliable assessment tool for students' written answers to artworks [24].

4- A study entitled "Assessment in the visual arts: challenges and possibilities", conducted by "Graham, Mark.(2019)", and explored the common challenges faces visual arts assessment and critically examined the advanced art portfolio in studio placement to determine how product-oriented evaluation can effect teaching and policy. The results of the study showed that, the art is difficult to judge, both advocacy policy and art education demand measures of students' art learning, and large-scale evaluations influence educational policy and finance at all levels [25].

5- A study entitled "Potentials and problem areas in assessment in visual arts education in Sweden", conducted by "Häikiö, Tarja Karlsson.(2021)", and discussed the teaching and assessing visual arts in Swedish compulsory school and highlighted the problem of assessing the teachers of the visual arts education. The study carried out on group discussions and seven interviews with teachers of visual arts about the assessment activities performed to produce two national assessment guides in the visual arts, and supplemental movies of evaluation instead of the Swedish national agency for education in years of 2012 and 2014. The results of the study showed that, a number of problems affecting the teaching of visual arts, which leads to varying degrees in teachers' assessment of students' artworks [26].

It is clear from the previous studies that, evaluating artworks using traditional methods is very difficult, and this is consistent with our current study, which made great efforts to reduce the role of the human element during the process of evaluating students' artworks in higher education institutions in Egypt. The most significant contribution of our study is the exploitation of modern technologies in the development of a hybrid android App which gives the automatic evaluation based on the content analysis approach a greater relative weight than the relative weight of art experts' evaluation.

2.2 Content Analysis Approach

This study proposes a hybrid mobile App to evaluate the artistic design of university students. The proposed mobile App is mainly based on the content analysis approach to extract the interior features from the student's art design image to automatically determine the closest similar artwork. Short notes on the content analysis approach will be provided in the following:

Throughout history, scientific studies have provided an enormous amount of approaches for analyzing digital data, the most prominent of which is the content analysis [27].

A review of the literature shows that, the content analysis approach has a long history in scientific studies, where it dates back to the eighteenth century in Scandinavia. Then, at the beginning of the twentieth century, it was employed as an analytical method for the first time in the United States, where it was initially used in the academic studies to analyze the content data either as a qualitative or quantitative approach.Subsequently, it was used as a quantitative research tool to analyze the qualitative data [28].

In literature, a number of definitions of content analysis approach are available [29]. The following are the most important of these definitions:

- It is a research methodology that explains the meaning of the data, whether it is a symbol, text, image, sound, ... etc[30].
- It is a method to make repeatable and valid inferences from the data to their usage contexts [31, 32].
- It is a research tool used to determine the presence of certain words, phrases, subjects, themes, or concepts in either historical or contemporary data [33].
- It is a reliable and learnable technique for the impartial, systematic and quantitative description of the clear content of communication [34].

In fact, content analysis approach has a wide range of goals, including [35]:

- Finding the relationships and patterns to communicate ideas and concepts.
- Grasping the intentions of others, whether an individual, a group or a whole organization.
- Recognizing the propaganda and discrimination in communication.
- Detecting the communication differences in various contexts.
- Analyzing the results of communication content, such as information flow or audience feedback.

The seven main elements required for content analysis include: words, characters, themes, paragraphs, concepts, items and semantics [36].In the light of the analytical goals and processes, the range of procedures involved in the content analysis approach is enormous [37]. According to [38], the main procedures of content analysis approach include: choosing elements based on study questions, designing and purifying groups, maintaining an objective and accurate classification, placing elements into categories, interpreting and summarizing results, and recording all steps performed. On other hand, according to [39], the key steps of content analysis approach include: identifying the research question, determining the research society, selecting the research participants, choosing the analysis parameter, creating categories, preparing a quantification system, training coders and determining reliability, finishing the coding activities, investigating the gathered data, and extracting conclusions from the outcomes.

In recent years, the content analysis approach is used in a numerous fields, such as [40]:

- Advertising and mass media studies,
- Literature and rhetoric,
- Ethnography and cultural studies,
- Sex and age topics,
- Sociology and politics,
- Psychology and mental skills,
- Socio- and psycholinguistics and
- Artificial intelligence.

3. PROBLEM DEFINITION

In the past, the educational visions towards education were limited, as some educators thought that the role of education was only to transfer knowledge from teacher to students, but with the development of educational theories, the vision of educators towards education also developed, where most educators agree that the educational process is a multi-element system whose main goal is to improve the learning outcomes by giving equal opportunities for all students to obtain a good quality education, especially in light of the vast amount of information available on the Internet.

Currently, in the Egyptian university education community, the arts have gained a major place and became a top priority in the curricula of specialized art colleges or other public colleges, where students in this stage of life can learn and develop other skills through the use of activities that show their creative abilities, such drama, music, dance, art, crafts, ... etc.

Practically speaking, many Egyptian art educators agree that assessment of students' artistic designs through traditional based human assessment methods faces lots of challenges, such as difficulty of assessment, divergence of interpretation among specialists and variation of assessment results between art evaluators. Therefore, a non-human method for assessing students' artworks in Egyptian higher education institutions has become an urgent need.

To overcome the former problems, the current study presents a new mobile-based assessment application for evaluating students' artworks in higher education institutions in Egypt.

4. PROPOSED APPLICATION

In general, the proposed mobile-based artworks assessment App includes a group of interdependent elements working together to achieve the desired objectives of the application.The details of the proposed mobile-based artworks assessment App are presented in three sub-sections: Overview, Methodology and Implementation. Each of these sections will be discussed in detail below.

4.1 App Overview

In this era, mobile based assessment is a new method of assessment that is conducted through smartphone devices based software applications to ensure a realistic assessment and to reduce personal biases.

This paper proposes a mobile-based artworks assessment App that is in line with the principle of reducing subjectivity in

assessing students' innovative works and shifting towards the automated assessment of students' drawings.

The proposed mobile-based artworks assessment App is categorized as a semi-automated method whose final output is produced by integrating the content analysis approach and the efforts of a well-known group of art experts in various Egyptian colleges of arts.

Practically speaking, the proposed mobile-based artworks assessment App performs many operations, the most important of which is the assessment of students' artistic creativity drawings. The broad outlines for students' artworks assessment operation are illustrated in Figure 1.

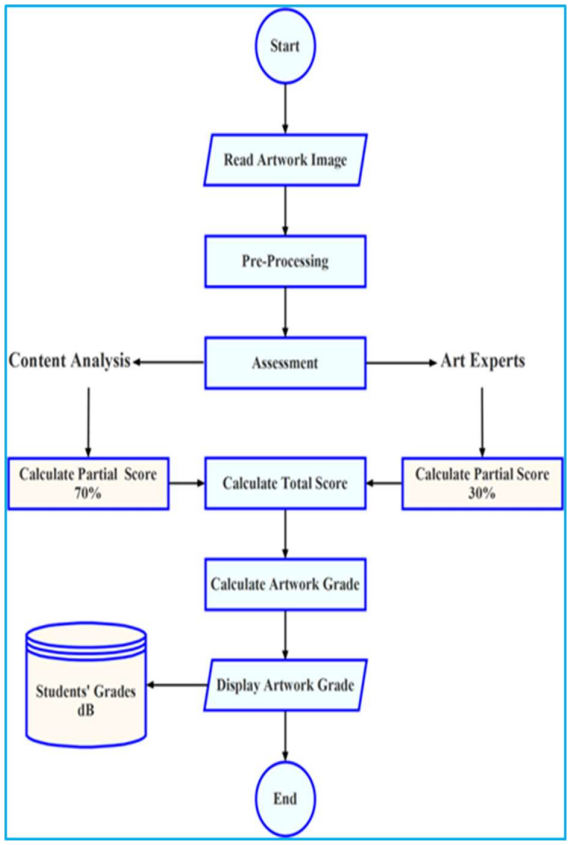

Fig 1: Steps of proposed mobile App

4.2 App Methodology

The proposed mobile-based artworks assessment App relied on the following proposed algorithm in assessing the students' artistic designs.

The Proposed Algorithm

Input: An image of the student's artwork design.

Output: The grade of the student's artwork design.

Procedures:

1. The image of the student's artistic design is acquired through various methods of image acquisition.

2. The captured or scanned image of the student's artwork design is processed via a wide range of digital image enhancement techniques to improve image quality and to obtain an adequate image.

3. The student's artwork design is assessed through the content analysis approach with a weight of 70 % of the total score and rated based on the classification shown in Table 1.

4. The student's artwork design is assessed through the art experts with a weight of 30 % of the total score and rated based on the classification shown in Table 2.

5. The total score of student's artwork design is calculated by adding the score values gained from the content analysis approach to the score values obtained from the art experts.

6.The final grade of student's artwork design is computed based on the classification shown in Table 3.

7. The final grade of student's artwork design is displayed for the viewer.

8. The final grade of student's artwork design is stored in the database for retrieval when needed.

Table 1: Converting scores of content analysis assessment into letter grades

Score	Grade
60 - 70	A+
50 - 59	A
40 - 49	B+
30 - 39	B
20 - 29	C+
10 - 19	C
Below	F

Table 2: Converting scores of art experts assessment into letter grades

Score	Grade
25 - 30	A+
20 - 24	A
15 - 19	B+
10 - 14	B
5 - 9	C+
2.5 - 4	C
Below	F

Table 3: Converting total scores of students' artwork assessment into final grades

Total Score	Grade
90 - 100	Hyper-Creative
80 - 89	Excellent
75 - 79	Very Good
65 - 74	Good
50 - 64	Passable

40 - 49	Poor
Below	Fail

4.3 App Implementation

To enable university faculty to utilize the proposed mobile-based artworks assessment App in assessing their students' artistic designs, an easy-to-use Graphical User Interface (GUI) has been designed.

Once the proposed mobile-based artworks assessment App is started, the login screen shown in Figure 2 is appeared to enable the university faculty member to sign-in using his secret institutional access data, including University ID and Password.

Fig 2: Login screen

From the above Figure, after the university faculty member enters the login data, the authentication process is performed.If faculty member has the proper permissions to access the proposed App, the Main screen shown in Figure 3 is appeared to enable the faculty member to select the required operation.

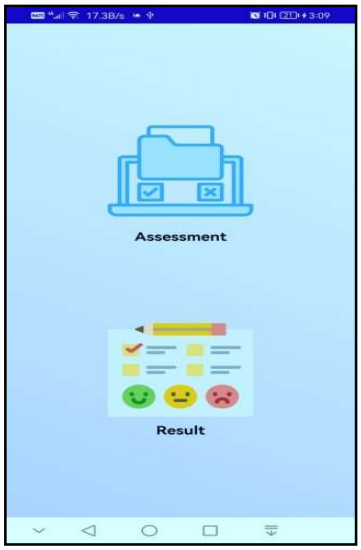

Fig 3: Main screen

From the above Figure, two operations are available: Assessment and Result. Firstly, once the faculty member clicks on the Assessment button, the artwork entry screen shown in Figure 4 is appeared to enable the faculty member to insert the student's artwork design image.

Fig 4: Artistic design acquiring screen

From the above Figure, three methods are available: Upload, Scan and Capture. Firstly, once the faculty member presses on the area designated to upload the student's artistic design, the image is uploaded manually from the cellular device by displaying the open dialog box and selecting the desired artwork image. Secondly, once the faculty member presses on the area designated to scan the student's artistic design, the image is scanned manually through the image scanner device.Thirdly, once the faculty member presses on the area designated to capture the student's artistic design, the image is captured directly by digital sensors of the smartphone camera.

After the artistic design image is acquired, the assessment screen shown in Figure 5 is appeared to evaluate the student's artistic design.

Fig 5: Student's artwork assessment screen

From the above Figure, the student's artistic design is evaluated in two integrated methods. In first method, the artwork image is sent to a group of art experts and the average value of their views is taken as an indicator of the quality of the student's artwork. In second method, the artwork image is automatically evaluated through content analysis approach.

Returning again to Figure 3, once the faculty member clicks on the Result button, the assessment results screen shown in Figure 6 is appeared to display the final assessment results of the student's artistic design.

Fig 6: Assessment result screen

From the above Figure, the details of the assessment results of the student's artwork are presented, including partial assessment score provided from content analysis approach, partial assessment score provided from art experts, total assessment score calculated by adding all partial scores together, and letter grade.

5. EXPERIMENTAL RESULTS

To estimate the effectiveness of the proposed mobile-based artworks assessment App, it underwent two different types of experiments. The details of both types are explained as follows:

5.1 Usability Test

Since user acceptance is one of the most critical factors in the successful implementation of software applications, the proposed mobile-based artworks assessment App was subjected to a usability test. The main objective of this testing type is to measure the acceptability of academic software experts to expand the scope of using the proposed mobile-based artworks assessment App in assessing the students' creative artworks in various Egyptian universities.

After completing the development phase of the proposed mobile-based artworks assessment App, it was presented to an academic group of software developers at Mansoura University to examine the four common key factors of usability estimation: "User Interface (UI)", "Effectiveness", "Ease of Use" and "Usefulness".

To obtain software developers' viewpoints on valid and invalid factors in the proposed mobile-based artworks assessment App, each member of the evaluation group was asked to complete a researcher-prepared form, which included a number of 5-point Likert scale questions covering the four predefined evaluation dimensions and scored as shown in Table 4.

Table 4: Points of questionnaire answers

Answer	Point
Strongly Agree	1
Agree	2
Neutral	3
Disagree	4
Strongly Disagree	5

The evaluation questionnaire forms were gathered from the evaluation group and revised by excluding the incomplete ones. The completed questionnaire forms were analyzed through descriptive statistical metrics. The overall percentage and acceptance level of predetermined evaluation dimensions were computed, presented in detail in Table 5 and shown in Figure 7.

Table 5: Results of usability test

Factor	Percentage of Acceptance
UI	96 %
Effectiveness	98 %
Ease of Use	97 %
Usefulness	99 %
Overall Average	**97.5 %**

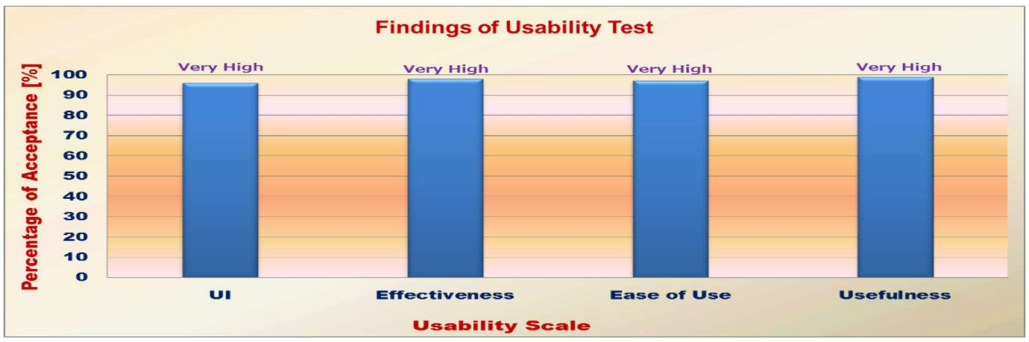

Fig 7: Outcomes of usability test

The results presented in Table 5 and displayed in Figure 7 reveal a minor differences between the acceptance percentages of the evaluation dimensions under test. The overall acceptance of perceived "UI" dimension is 96 %, the overall acceptance of perceived "Effectiveness" dimension is 98%, the overall acceptance of perceived "Ease of Use" dimension is 97 % and the overall acceptance of perceived "Usefulness" dimension is 99 %. In addition, the obtained results also indicate that the overall acceptance of art experts of all dimensions rises above 97 %, which is classified highly admission.

Finally, it can be concluded from these findings that, the proposed mobile-based artworks assessment App gained acceptance of all academic software developers and has fully met the pre-defined usability criteria.

5.2 Artworks Assessment Accuracy Test

Once the activities of the usability test were successfully conducted, the proposed mobile-based artworks assessment App moved to another type of experiments called accuracy test. The main objective of this testing type is to measure the performance accuracy of the proposed mobile-based artworks assessment App in assessing the students' artistic creativity with new methodology.

This test was conducted on a random sample of 1st year Art Education Department students of Faculty of Specific Education of Mansoura University during the second semester. This test involved an artistic dataset composed of 100 visual artwork images on various topics in the drawing course scheduled for students of first year of Art Education Department of Specific Education Faculty, Mansoura University.

In this test, each student in the test sample was asked to draw an art design with specified specifications on a sketchbook over a certain period of time. After the end of the testing period, the artistic designs of all students were obtained through various image acquisition techniques and sent to the handheld device designed to perform activities of evaluating students' artistic designs at two levels.

In the first level of assessment, the student's artwork was assessed using a content analysis approach to determine the closest similar artistic design and the score of this level represents 70 % of the total course score.

In the second level of assessment, the student's artwork was assessed by a group of art experts, who randomly selected from the App database, where the student's artwork was sent to ten experts along with an electronic assessment form prepared by the researcher with the help of art specialists to assess the student's artwork in major design principles and technical design elements. The scores of art experts were recorded and the average score was used as an indicator for their viewpoints and the score of this level represents 30% of the total course score.

The scores of artworks assessment of tested students through the content analysis approach were converted into letter grades according to the classification previously summarized in Table 1, likewise the art experts assessment scores were converted into letter grades according to the classification previously summarized in Table 2. Finally, the total scores were computed and converted into letter grades according to the classification previously summarized in Table 3 and were presented in Table 6 and shown in Figure 8.

Table 6: Matching level of students' artworks assessment by content analysis approach and art experts

Artistic Design No	Content Analysis		Art Experts		Matching Level
	Score	Grade	Score	Grade	
1	55	A	22	A	Very High
2	28	C+	7	C+	Very High
3	66	A+	23	A	High
4	48	B+	17	B+	Very High
5	10	C	6	C+	High
6	35	B	18	B	Very High
7	22	C+	2	C	High
8	69	A+	26	A+	Very High
9	8	F	2	F	Very High
10	24	C+	25	A+	Moderate
…	…	…	…	…	…
100	42	B+	14	B	High

Table 7: Total scores and final grades of students' artworks assessment using proposed mobile App

Artistic Design No	Total Score	Final Grade
1	77	Very Good
2	35	Fail

3	89	Excellent
4	65	Good
5	16	Fail
6	53	Passable
7	24	Fail
8	95	Hyper-Creative
9	10	Fail
10	49	Poor
…	…	…
100	56	Passable

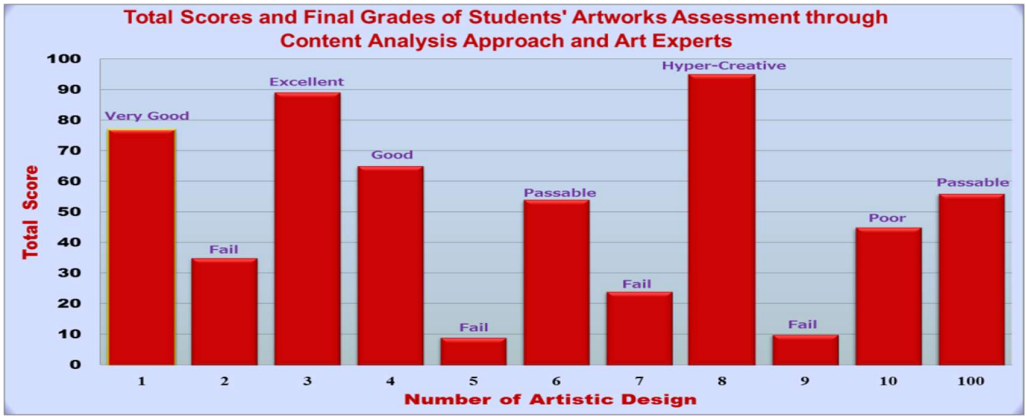

Fig 8: Outcomes of students' artworks assessment through proposed mobile App

It is clear from the above outcomes that, the content analysis approach performed well more than our expectations in the assessment of students' artistic designs, where the majority of its results agreed with the assessment results of the selected group of art experts.

Also, the previous outcomes indicate that the proposed mobile-based artworks assessment App achieved a high level of accuracy in assessing the students' artworks of Mansoura university. Therefore, the scope of its application can be extended to various Egyptian universities.

Based on the preceding outcomes, it can be concluded that the proposed mobile-based artworks assessment App is a nucleus for other researchers who have the same research interests with regard to the employment of modern technologies in evaluating creative works in general and artistic designs in particular.

6. CONCLUSION & FUTURE WORK

Over the past years, subjective impressions have negatively affected the grades of students' artworks, as the same student art design was given varying scores when assessed by different art experts.

Due to the low confidence in the results of assessing students' artworks with traditional assessment methods, a new trend has emerged that strongly focuses on nurturing creativity and applying advanced technological means in assessing the creative visual artworks of higher education students.

The current study presents a new mobile App to develop assessment methodologies of students' artistic designs in Egyptian university institutions. The proposed mobile App integrates content analysis approach and art experts point of view with different rates, where the percentage of content analysis approach was 70 % of the total course score, while the percentage of art experts opinions was 30 % of the total course score.

The evaluation process of the proposed mobile-based artworks assessment App is performed in two phases of testing to estimate usability and accuracy measurements. The results of usability test confirmed that, the proposed mobile-based artworks assessment App is highly usable by potential end users in various higher education institutions of Egypt. On other hand, the results of the accuracy test showed that, the proposed mobile-based artworks assessment App is accurate enough in assessing students' creative artworks.

Finally, we conclude from the obtained experimental results that, the proposed mobile-based artworks assessment App is a nucleus for other peer researchers who are interested in the automatic assessment of university students' creative works in general and works of art in particular.

The future work aims to make the proposed mobile-based artworks assessment App is fully automated in assessing students' creative artwork without any intervention form art experts. Moreover, the future efforts will also strive to enable college students to replace traditional drawing methods with computer graphic design software -such as, Adobe Photoshop, Illustrator, Corel Draw, Photo-Paint, ... etc- due to their powerful capabilities that help artists easily create creative professional artworks.

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