LET THE ACID AND BASE FLASH OUT!

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DOI: https://doi.org/10.37178/ca-c.22.1.184

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ABSTRACT

The purpose of this research is to design and develop the Acid-Base e-Flashcard (ABeF) and investigate student teachers' perception towards the usability of ABeF. The research design of this study is design and development research. The ABeF development process was based on five phases in ADDIE model. Three instruments were used in this research, which are the content validity evaluation form, reliability questionnaire and usability questionnaire. Two Chemistry lecturers have been appointed to validate the content validity of ABeF. A total of 32 semester seven student teachers from Bachelor of Education (Chemistry) program were chosen as the respondents to identify the reliability of ABeF and usability questionnaire during the pilot study. A total of 201 student teachers from the same program were involved in the field study. The findings show that the Cohen kappa coefficient value for the validity of ABeF was 1.00. The overall reliability value for ABeF was 0.98. The mean values for the usability of ABeF in terms of usefulness, satisfaction and ease of use were 3.82 (SD = 0.39), 3.84 (SD = 0.37) and 3.84 (SD = 0.37), respectively. In conclusion, ABeF has high validity, reliability and usability index. The implication of this study is ABeF can help the teachers and student teachers to teach acid and base topic in a more interesting way. Besides, form four Chemistry students can learn acid and base topic better with the use of ABeF that can be visualized.

Keywords: Acid Base; e-Flashcard; ADDIE Model; Validity; Usability, Student Teacher

INTRODUCTION

Acid and base is an important topic in the middle and upper high school's Chemistry curriculum. According to Sesen and Tarhan [1], acids and bases are linked to many chemistry concepts, such as nature of matter, solutions, stoichiometry, chemical reaction, electrochemistry and chemical equilibrium. Conventional way of teaching this topic normally is by explaining the definition of acid and base using Arrhenius, Bronsted-Lowry and Lewis theories [2, 3]. This typical way of delivering acid-base concepts resulting several consequences, for instance: students' alternative conceptions [4], difficulties in transferring and applying knowledge, misunderstanding about the development of a historical model [5]. Acid and base topic has posed many problems to students from different background [6]. Students have difficulties in understanding abstract acid and base concepts [6-8].

A needs analysis survey had been carried out earlier among the secondary science stream students to identify which chemistry topic is the most difficult to learn. Figure 1 shows that acid, base and salt topic is the most difficult topic among the topics in the form four and form five Chemistry syllabus. This result is in line with previous studies carried out in Malaysia which showed that acid, base and salt concepts are the top three challenging topics to be learned in the syllabus [9, 10]. The students are struggling to understand acid and base topic as it is too difficult, and teachers are having challenges delivering the concepts. Conventional teaching strategies contributed to students' difficulty in understanding chemistry topics [11]. The lack of learning aids and unfamiliar language [12] make acid and base topic separated from real life. Therefore, teachers need to deliver the acid and base content in other alternative approaches like collaborative learning, self-learning, and problem-based learning via interactive multimedia, which engages students actively in the teaching and learning process [13, 14].

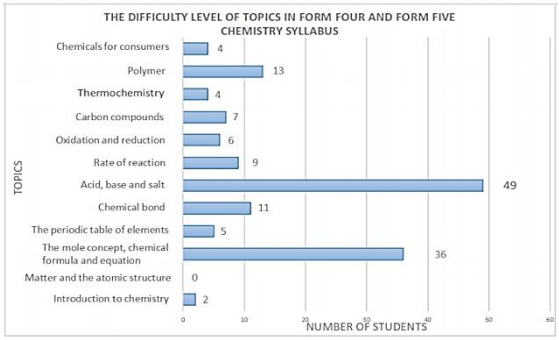

Figure 1. The Difficulty Level of Topics in Form Four and Form Five Chemistry Syllabus

Technology is important in our daily life because it is used in all areas of life. According to Dinc [15], education field has been touched by the technology's magic. Miranda and Russell [16] stated that teachers believe that technology is helpful to reach the determined objectives. The use of technologies makes students more active and creative during the teaching and learning process.

Flashcard is a well-recognized educational tool for learning basic information [17]. Colbran, Gilding, and Colbran [18] stated that utilizing flashcard as a learning technique encourages self-assessment, formative assessment, self-identification of misconceptions and enhance memory testing. The flashcard combined with the use of technology can make the teaching and learning sessions more interesting and interactive.

In this study, a digital flashcard named Acid-Base e-Flashcard (ABeF) was developed to overcome the problems of teachers and students in acid and base topic. ABeF contains Quick Response codes (QR codes) which are small squares with black and white patterns. By scanning the QR codes, students can quickly and directly access to the web pages through their smartphones. The use of QR codes prevent students from wasting time on searching irrelevant information [19]. The process of making and scanning QR codes are easy for both students and teachers. This enhances the use of QR codes in education. Students can learn more about acid and base topic through video files, simulation of acid-base titration, web pages and quizzes by scanning the QR codes in ABeF. They can remember concepts, details and relationships among the concepts more clearly because ABeF promotes studying through active recall [20]. Hence, this study aims to develop ABeF, identify the content validity and reliability of ABeF, determine the usability of ABeF in terms of usefulness, satisfaction and ease of use.

LITERATURE REVIEW

Çetingül and Geban [21] stated that in high school curriculum, understanding acids and bases have a central role in understanding other concepts clearly, such as chemical reaction, especially oxidation and reductions, organic chemistry and acid-base equilibrium. However, majority of the students are facing problems in understanding the acid and base topic. Students were having difficulties when they try to relate concentration with concept of acidity, basicity and pH [21]. Students often stated that concentrated acids and bases are strong while dilute acids and bases are weak. Most of the student determined the characteristic of a solution by looking at the pH value [22]. Students have problems in understanding the pH values, concept of acidity, basicity and titration process. ABeF can help the students by showing important key points, interesting videos and simulation of acid-base titration. Students can learn more about acid and base topic by scanning the QR codes in ABeF.

Besides, Uçak [19] stated that the uses of QR codes prevent students from wasting time on searching irrelevant information and hence increases efficiency in learning environments. Not only that, QR codes on ABeF prevent paper wastage and helps the students access relevant resources more effectively. By scanning the QR codes on the learning materials, students can directly access to the online platform via smartphones [23] . Students can access the material on the related web pages quickly and directly. According to Uçak [19], most of the science teachers claimed that QR codes in teaching tools aroused engagement and interest in students. Science teacher recommended that QR codes could be used in assessment of the class, game-based learning, laboratories, assignments, school corridors, and classroom boards [19]. The teachers had listed the benefits of QR codes such as easy preparation, short preparation time, updateable, portability, preventing paper wastage, timesaving and providing direct access to targeted content. Students agreed that the QR codes are quite handy and easy to use. Students prefer to use the codes rather than writing down notes in their notebook. It is faster and easier since they can read it repeatedly from their phones. Hence, ABeF consists of QR codes that would link to the useful digital information of acid and base. This ABeF was developed based on ADDIE Model and usability of ABeF was investigated.

Usability is a quality attribute that assesses how easy users interface is to use [24]. It refers to ways for improving ease-to-use during the design process. Usability design considers who the users are, what they know, how they learn and the context in which they use a given product. It can be measured by usefulness, satisfaction and ease of use.

Usefulness is defined as an individual believes that using a certain system would enhance his or her task performance [24, 25]. Results on the usefulness of virtual laboratory package shows that pre-service student teachers perceived the package to be useful in learning and teaching of secondary school physics concepts [26]. This finding was parallel with the suggestion of Davis [25] and the views of Abu-Dalbouh [27] that users of certain technology must recognize it to be useful in enhancing their task performance before using it. The finding also in line with the earlier result of Alharbi and Drew [28] who reveal positive academics' perception of the usefulness of Learning Management System. Pre-service student teachers perceived the virtual laboratory package was useful because they believe it would enhance their teaching and make them teach physics efficiently.

Locke [29] defined satisfaction as an affection towards an object or emotional response. According to Davis [25], satisfaction was strongly related to the usage (actual or predicted). Users believe that e-learning may influence performance and apprehension of the system as relatively easy can trigger a positive view of satisfaction [30]. In addition, user satisfaction may appear as an essential determinant of the

intention to use certain e-learning systems. Satisfaction has a significant positive effect for e-learning systems.

According to Spacey [31], ease of use is the usability of a service, product, tool, environment or process. Perceived ease of use is explained as the degree to which a person believes that using a certain technology is free of mental and physical effort [26]. Findings on ease of using virtual laboratory package shows those respondents perceived the package was easy to use. This finding was parallel with the recommendation of Davis [25] who introduced the Technology Acceptance Model (TAM), the views of Abu-Dalbouh [27] that using a certain technology must be free of mental and physical effort. This finding was in line with the earlier result of Alharbi and Drew [28] who found that academics discovered Learning Management System is easy to use.

METHODOLOGY

Research Design

The research design of this study is design and development research. ABeF was developed and survey was conducted to investigate the usability of ABeF from the perspective of student teachers. This study used the ADDIE Model as the instructional design model to develop ABeF according to five phases of ADDIE Model [32], which are (i) Analysis phase, (ii) Design phase, (iii) Development phase, (iv) Implementation phase, and (v) Evaluation phase.

Sampling of Respondents

There are three sampling techniques used in this study which are purposive sampling, cluster random sampling and simple random sampling techniques. The sampling techniques are used to obtain respondents in the study of validity, reliability and usability of ABeF. In this study, content validity of ABeF was checked by two experts from Department of Chemistry using purposive sampling. The purposive sampling technique, also called judgment sampling, is the deliberate choice of a participant due to the qualities the participant possesses [33].

In this study, student teachers were selected from Bachelor of Education (Chemistry) program to evaluate the reliability of digital flashcard by using cluster random sampling technique. Cluster sampling involves dividing the population into subgroups, but each subgroup should have similar characteristics to the whole sample. There are seven groups of student teachers in Chemistry program. Semester seven group was randomly selected as the respondents to evaluate the reliability of ABeF during the pilot study.

The sample for the usability study consisted of the student teachers in semester one to six of Bachelor of Education (Chemistry) program in one of the universities in Malaysia who were selected randomly. By using simple random sampling technique, every member in the population has same chance of being chosen [34]. The population of usability study is 406 people and researcher selected 201 of them based on Krejcie and Morgan [35] sample size determination table (Figure 2). Table I shows the sampling techniques according to the purpose of data collection.

N	S
220	140
230	144
240	148
250	152
260	155
270	159
280	162
290	165
300	169
320	175
340	181
360	186
380	191
400	196
420	201
440	205
460	210

Figure 2. Sample Size Determination Table [35]

Table I

Sampling Techniques According to the Purpose of Data Collection

Purpose	Respondents	Sampling Technique
Content Validity	Two Chemistry lecturers	Purposive sampling
Reliability	32 Chemistry student teachers	Cluster sampling
Usability	Population: 406 Chemistry student teachers Sample: 201 Chemistry student teachers [35]	Simple random sampling

Instrument

There are three instruments used in this research to collect the data. The instruments are content validity evaluation form, reliability questionnaire and usability questionnaire.

Content Validity Evaluation Form

The content validity evaluation form was given to two experts from Department of Chemistry to validate the content validity of ABeF during the implementation phase. The items in content validity evaluation form were based on the content in the ABeF. The content validity evaluation form has four sections. Part A is about the demographic of experts, Part B is about the face validity of digital flashcard, Part C is about the content validity of digital flashcard and Part D is about the overall review. Content validity of ABeF was processed by using the Cohen's kappa method. Table II shows the Likert scale used in content validity evaluation form and Table III shows the relationship between the value of kappa and strength of agreement [36].

Table II

Four-point Likert Scale Used in Content Validity Evaluation Form

Scale	Interpretation
1	Strongly disagree
2	Disagree
3	Agree
4	Strongly agree

Table III

Interpretation of Cohen's Kappa Coefficient [36]

Value of Kappa	Strength of Agreement
< 0.00	Very weak
0.00 – 0.20	Weak
0.21 – 0.40	Moderately weak
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81 – 1.00	Very good

Reliability Questionnaire

Reliability questionnaire consisted of items regarding content and activities delivered in ABeF and learning standards of each subtopic in acid and base. Learning standards describe the educational objectives that need to be achieved by the learners. Learning standards are concise, written descriptions of what students are expected to know and be able to do at a specific stage of their education. The distribution of items in reliability questionnaire is shown in Table IV. Validity of reliability questionnaire was checked by three experts before the pilot test. Item Content Validity Index (I-CVI) for all the items were 1.00. Lynn [37] developed criteria for item acceptability that incorporated the standard error of the proportion. She recommended that with a panel of ''five or fewer experts, all must agree on the content validity for their rating to be considered a reasonable representation of the universe of possible ratings''. In other words, the I-CVI should be 1.00 when there are five or fewer judges.

The questionnaire was given during pilot test to obtain the reliability coefficient of the digital flashcard. Table V shows the relationship between Cronbach's alpha values and reliability level [38].

Table IV

Item Distribution in Reliability Questionnaire

Part	Item	Total item
A	Demographic information	2
B	The Role of Water in Showing Acidic and Alkaline Properties	20
C	pH Value	14
D	Strength of Acids and Alkalis	13
E	Chemical Properties of Acids and Alkalis	11
F	Concentration of Aqueous Solution	10
G	Standard Solution	9
H	Neutralisation	25

Table V

Interpretation of Cronbach's Alpha Coefficient [38]

Cronbach's alpha coefficient range	Reliability Level
< 0.6	Poor
0.6 to < 0.7	Questionable
0.7 to < 0.8	Acceptable
0.8 to < 0.9	Good
> 0.9	Excellent

Usability Questionnaire

Usability questionnaire is used to obtain perceptions of sample about the usability of ABeF. Usability questionnaire was given to the respondents to evaluate the usability of ABeF in terms of usefulness, satisfaction and ease of use. The questionnaire was adapted from Lund's [39] study. This questionnaire comprises of four parts. Part A is about the demographic of respondents, for example the gender and races. The result of the questionnaire is confidential and only used for the purpose of this study. Part B is about the usefulness of ABeF. Part C is about the satisfaction of ABeF and part D is about ease of use of ABeF. There are five items in each part. Table VI shows the item distribution in usability questionnaire and Table VII shows the interpretation of usability mean scores. Usability questionnaire was checked by three experts to obtain the validity index. I-CVI for all the items in the questionnaire were 1.00. The reliability coefficient value for the usability questionnaire was 0.734.

Table VI

Item Distribution in Usability Questionnaire

Part	Item	Total Items
A	Demographic Information	3
B	Usefulness	5
C	Satisfaction	5
D	Ease of Use	5

Table VII

Interpretation of Usability Mean Scores [40]

Mean Score	Interpretation
1.00 – 2.00	Low
2.01 – 3.00	Average
3.01 – 4.00	High

Development of ABeF

In this study, a digital flashcard named as ABeF was developed based on five phases of ADDIE Model.

Analysis Phase

According to Branch [32], the purpose of the analysis phase is to identify the probable causes for a performance gap. Researcher is able to determine if instruction will close the performance gap, propose degree to which instruction will close the gap, and recommend strategies to close the performance gap based on empirical evidence about the potential for success. The analysis phase consists of four elements, which are (i) identifying the difficult topic, (ii) identifying the learning methods, (iii) identifying the digital flashcard development objectives and (iv) confirming the intended audience.

In order to identify the difficult topic among the curriculum, a need analysis was carried out which involved a total of 146 respondents consisting of form four and form five Chemistry students. According to need analysis, acid, base and salt is the most difficult topic among the topics in the form four and form five Chemistry syllabus (Figure 1). Acid and base concept is in chapter six combined with the salt topic.

In this study, researcher focused on the acid and base topic only. Salt topic is excluded because it is considered as another topic after the students have mastered acid and base topic. Seven subtopics of acid and base are included in the digital flashcard, which are (i) The role of water in showing acidic and alkaline properties, (ii) pH value, (iii) Strength of acids and alkalis, (iv) Chemical properties of acids and alkalis, (v) Concentration of aqueous solution, (vi) Standard solution, and (vii) Neutralisation. Besides asking about difficult topics in chemistry syllabus, the need analysis also requested students to choose the learning methods they prefer in learning chemistry.

According to need analysis (Figure 3), there were 57 students who preferred game-based learning while 44 students and 31 students preferred model or simulation and multimedia respectively. Previous studies [41-43] showed that game-based learning was more assessment-based where games were designed mainly to assess players' performance. The intention of researcher was to help students develop the basic acid-base concepts. Hence, researcher had chosen simulation and multimedia learning methods as a reference to develop the ABeF.

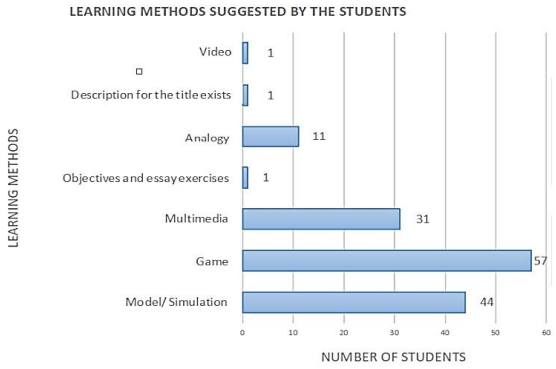

Figure 3. Learning Methods Chosen by the Students

The objective for the development of ABeF is help students learn acid and base topic easier with the use of Information and Communication (ICT) and simulation. According to Julie Phelps and Altabbakh [17], flashcard is an educational aid for students remembering information. Therefore, researcher utilized flashcard with the use of multimedia and acid base titration simulation to help the students in learning acid and base topic. ABeF was developed to help the students to master the acid and base topic in a more interesting way.

The target audience for ABeF should be the form 4 students in secondary school, but due to COVID-19, researcher cannot carry out the research at school. Hence, researcher investigated the perception of student teachers on ABeF in one of the universities in Malaysia. Student teachers are valid to give their perception on ABeF because they used to be form 4 Chemistry students and they are currently taking the Chemistry education program in university.

Design Phase

The purpose of the design phase is to verify the desired performances and appropriate testing methods [32]. Researcher needs to design the instructional goals, design the digital flashcard, search and select learning materials for the digital flashcard and design the user manual of ABeF. Researcher used form four Chemistry Textbook [44] as the main reference for ABeF development to meet the content standards provided by the Ministry of Education (MOE).

There are 18 learning standards to be achieved by students in seven content standards related to acid and base concept (Table VIII).

Table VIII

Learning Standards to Be Achieved

Learning Content		Learning Standards	
6.1	The role of water in showing acidic and alkaline properties	6.1.1	Defining acid and alkali
		6.1.2	Stating the meaning of basicity of an acid
		6.1.3	Investigating the role of water in showing acidic and alkaline properties through experiment
6.2	pH value	6.2.1	Stating the meaning of pH and its uses
		6.2.2	Calculating the pH values of acids and alkalis
		6.2.3	Investigating the relationship between pH value and the concentration of hydrogen ions and hydroxide ions through experiment
6.3	Strength of acids and alkalis	6.3.1	Defining strong acid, weak acid, strong alkali and weak alkali
		6.3.2	Explaining the strength of acid and alkali based on its degree of dissociation in water
6.4	Chemical properties of acids and alkalis	6.4.1	Understanding the chemical properties of acids by carrying out the reactions between (i) acid and base, (ii) acid and reactive metal, and (iii) acid and metal carbonate
		6.4.2	Understanding the chemical properties of alkalis by carrying out the reactions between (i) alkali and acid, (ii) alkali and metal ion, and (iii) alkali and ammonium salt
6.5	Concentration of aqueous solution	6.5.1	Stating the meaning of concentration of aqueous solution
		6.5.2	Solving numerical problems involving concentration of solution
6.6	Standard solution	6.6.1	Stating the meaning of standard solution
		6.6.2	Understand the preparation of a standard solution through the activity: (i) from a solid substance, and (ii) through dilution of an aqueous solution
		6.6.3	Solving numerical problems involving preparation of a standard solution by dilution
6.7	Neutralisation	6.7.1	Stating the meaning of neutralisation

		6.7.2	Determining the concentration of an unknown solution through titration method
		6.7.3	Solving numerical problems involving neutralisation

Next, research started to design the digital flashcard. This digital flashcard is related to the acid and base topic in the form four Chemistry Syllabus and was named Acid-Base e-Flashcard (ABeF). It was made of manila card with laminated and binder ring with standard size (6.92cm x 10.89cm). Soft color images was set as the background of ABeF (Figure 4) because soft color images is not too bright or too dark and will not distract from the content. According to Jones [45], color creates ideas, expresses messages, spark interest and generate certain emotions. Soft colors tend to set a happy and positive mood [45].

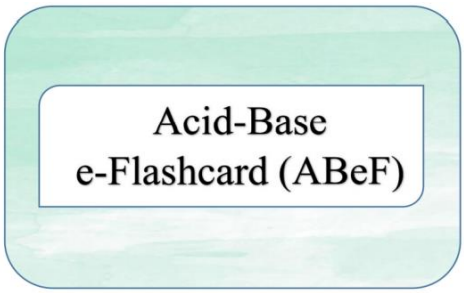

Figure 4. Front Cover Design of ABeF

The materials used in this digital flashcard are in the form of notes, webpages, videos, simulator, images, QR codes and questions for quizzes. The notes in ABeF were based on the form four Chemistry textbook. Researcher searched the relevant webpages about the acid and base topic and also the acid-base simulator. The images displayed in the ABeF were randomly selected from the Google. Videos in the ABeF were downloaded from the YouTube. The sources for the videos are listed in the reference section to give appreciation to the original creators. Researcher generated the QR codes after selecting the materials. Google, YouTube, YouTube Cutter, Google Drive, Quizizz, Pinterest, QR Code Generator and WPS Office were used to develop the ABeF.

In order to help students to use ABeF effectively, the procedure of using the digital flashcard is described in detail using diagram and simple instructions in user manual (Figure 5).

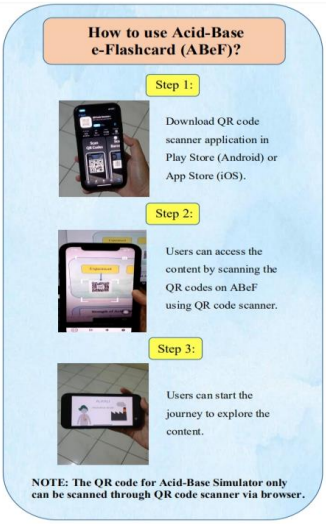

Figure 5. User Manual of ABeF

Development Phase

The purpose of the development phase is to generate selected learning resources [32]. In this phase, researcher developed the ABeF using the Quizizz, QR Code Generator, Pinterest and WPS Office. Researcher used the Quizizz website to create the quizzes for each topic in the ABeF. Researcher generated the QR code using QR Code Generator to deliver the learning material in ABeF. ABeF contains QR codes that link to videos, simulation of acid base titration and webpages of acid and base. Besides, QR codes for the quizzes for each subtopic created by Quizizz were also generated. Next, Pinterest website was used to select the background for ABeF and then WPS Office was used to design ABeF card. Some completed ABeF cards are shown in Figure 6.

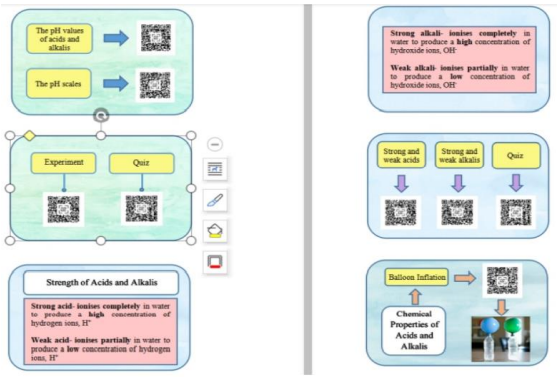

Figure 6. Some Completed Cards of ABeF

Implementation Phase

The purpose of the implementation phase is to prepare the learning environment and engage the students [32]. This phase is important to test ABeF that was developed to identify issues that are inherent during the design and development phase without the researcher knowing. Besides, it also ensured that the ABeF is systematic and effective. Researcher appointed two Chemistry lecturers to validate the content of ABeF. After obtaining the content validity for ABeF, researcher carried out pilot study to check the reliability of ABeF. Due to the COVID-19 pandemic, face-to-face data collection method cannot be done. Hence, a short video explaining about the features of ABeF and how to use the ABeF was created and sent together with Google Forms via WhatsApp to the respective respondents. Respondents were required to watch the ABeF explanation video and answer the reliability questionnaire and usability questionnaire. They were given two weeks to answer both questionnaires.

Evaluation Phase

The continuation of the implementation phase is the evaluation phase. The purpose of the evaluation phase is to assess the quality of the instructional products and processes, both before and after implementation [32]. There are two main types of evaluation used in the ADDIE approach, (1) Formative Evaluation and (2) Summative Evaluation.

Formative evaluation is the process of collecting data that can be used to revise the instruction before implementation. The purpose of formative evaluation is to determine the potential effectiveness of learning resources under development and to identify any learning resources or parts thereof that need to be revised [32]. This phase aims to get feedback that will help improve the overall quality of the ABeF being

developed. Comments were given and corrections had been done during analysis, design, development and implementation phases.

Summative evaluation is the process of collecting data following implementation in order to determine its effectiveness [32]. After obtaining the content validity, reliability of ABeF and usability questionnaire, researcher distributed the usability questionnaire to the respondents to study the usability of ABeF. COVID-19 pandemic restricted the movement of researcher to meet the respondents face-to-face, hence the Google Forms of usability questionnaire and explanation video were distributed to the respondents via WhatsApp messaging app. The respondents were required to answer the usability questionnaire for about four weeks. Researcher would like to determine the usability mean score for ABeF in terms of usefulness, satisfaction and ease of use from the perspective of student teachers.

RESULTS AND DISCUSSION

Content Validity of ABeF

The content validity of ABeF was checked by using the content validity evaluation form and analyzed by using the Cohen's kappa method. The formula for calculating the coefficients of the agreement [36] is as shown below.

$$K = (fa-fc) / (N-fc)$$

Where,

K = A coefficient of Agreement

fa = the number of units in which the judges agreed

fc = the number of units in which is expected by chance (50% of N)

N = the number of units coded

There are 40 items in the content validity evaluation form. Likert scale 1 to 4 are used to represent experts' consent scores. Two experts agreed all the items in the evaluation form and the total kappa agreement value coefficient average between two experts was 1.00. The calculation of Cohen's kappa coefficient agreement value between two experts is shown in Table IX.

According to Rust and Cooil [36], the kappa agreement value between 0.81 and 1.00 is very good. It was proven that the ABeF had a very good kappa agreement value for content validity. Content validity is the extent to which the items on the instrument and the scores from these items are representing all possible items that could be asked about the content or skill [46]. The more the scale items are representing the domain of the concept being measured, the greater the content validity [47]. Mohajan [48] stated that there is no statistical test to decide whether a measure appropriately covers a content area, content validity normally depends on the judgment of experts in the particular field. The obscure and unclear questions can be amended, and the weak and non-functioning questions can be excluded by the advice of the experts.

Table IX

The Calculation of Cohen's Kappa Coefficient Agreement Value between Two Experts

Kappa Agreement Value Coefficient Expert 1	Kappa Agreement Value Coefficient Expert 2	Total Kappa Agreement Value Coefficient Average
fa = 40	fa = 40	
fc = 20	fc = 20	
N = 40	N = 40	
K = (fa-fc) / (N-fc)	K = (fa-fc) / (N-fc)	
K = (40-20) / (40-20)	K = (40-20) / (40-20)	K = (1+1) / 2
K = 1.00	K = 1.00	K = 1.00

Reliability of ABeF

Reliability measures consistency, precision, repeatability and trustworthiness of a research [49]. The result of a researcher is considered reliable if consistent results have been obtained in identical situations but different circumstances [48]. In this study, reliability questionnaire was given to all the semester seven student teachers to obtain the reliability of ABeF. Distribution of items in the reliability questionnaire were shown in Table IV. This questionnaire used four-point Likert scale from strongly agree to strongly disagree. Table X shows the reliability coefficient value for each part in the questionnaire.

Table X

Reliability Coefficient Value for Each Part in the Questionnaire

No	Part	Cronbach's Alpha
1.	The Role of Water in Showing Acidic and Alkaline Properties	0.96
2.	pH Value	0.87
3.	Strength of Acids and Alkalis	0.86
4.	Chemical Properties of Acids and Alkalis	0.87
5.	Concentration of Aqueous Solution	0.86
6.	Standard Solution	0.78
7.	Neutralisation	0.95
Overall reliability value		0.98

The Cronbach's alpha coefficient value for the role of water in showing acidic and alkaline properties part obtained the highest value which was 0.96. This indicates the

respondents agreed that they can understand all the contents for the role of water in showing acidic and alkaline properties topic in the ABeF. Respondents agreed that they were able to scan the QR codes and answered the quizzes for this topic. ABeF contains (QR codes) which are small squares with black and white patterns. By scanning the QR codes, students can quickly and directly access to the web pages through their smartphones.

In addition, the Cronbach's alpha coefficient values for the pH value part and chemical properties of acids and alkalis part obtained the same readings of 0.87. Respondents agreed that the content in both parts is relevant to the topic. Besides, the strength of acids and alkalis part and concentration of aqueous solution part gained the same readings of 0.86. Respondents were able to access to the videos by scanning the QR codes on the ABeF. After scanning the QR codes, respondents can learn more details and information for both topics.

The standard solution part obtained the lowest Cronbach's alpha coefficient value, which was 0.78. According to Downing [50], for high-stakes settings (e.g., licensure examination), reliability value should be greater than 0.9, whereas for less important situations values of 0.7 or 0.8 can be acceptable. The neutralisation part gained a reading of 0.95. This indicates that the respondents were able to learn the neutralisation topic through the simulation of acid base titration. Students can choose to carry out a strong acid with strong base titration or any combination of strong and weak acid base titrations. The simulator allows students to run the titration experiment on a computer before taking part in the real experiment. This can help the students to become more confident and familiar with the procedures in the laboratory.

The overall reliability value for ABeF was 0.98, which represented excellent level based on the interpretation of Cronbach's alpha coefficient (Table V). The general rule for reliability is that reliability index greater than 0.8 are considered as high [50]. The coefficient of reliability falls between 0 and 1, with perfect reliability equalling 1, and no reliability equalling 0 [48]. The better the reliability is performed, the more accurate the results, which increases the chance of making correct decision in research [48]. Reliability is necessary, but not a sufficient condition for the validity of research. The reliability coefficient value for ABeF was 0.98 and this shows that the ABeF is acceptable and reliable. The ABeF can be used by the intended audience.

Usability of ABeF

The usability questionnaire focuses on the usability of ABeF in terms of usefulness, satisfaction and ease of use. Researcher found the related usability questionnaire from Lund's [39] study. Usability questionnaire was analyzed descriptively via mean, standard deviation, frequency and percentage.

Usefulness of ABeF

In this study, usefulness of ABeF was studied through five items in the usability questionnaire. Table XI shows the distribution of item agreement scales for the usefulness of ABeF.

Table XI

Distribution of Item Agreement Scales for the Usefulness of ABeF

No	Item	Agreement Scale Frequency (%)			
		1	2	3	4
1	ABeF helps me to be more productive in the learning of acid and base.	0 (0.00%)	0 (0.00%)	34 (16.92%)	167 (83.08%)
2	ABeF is useful in the learning of acid and base.	0 (0.00%)	0 (0.00%)	34 (16.92%)	167 (83.08%)
3	ABeF saves my time when I use it to learn acid and base topic.	0 (0.00%)	0 (0.00%)	37 (18.41%)	164 (81.59%)
4	ABeF meets my needs in the learning of acid and base.	0 (0.00%)	0 (0.00%)	41 (20.40%)	160 (79.60%)
5	ABeF enables me to simulate acid and base titration.	0 (0.00%)	0 (0.00%)	36 (17.91%)	165 (82.09%)
			Mean: 3.82 Standard Deviation: 0.39		

According to Table XI, the findings of the study show that ABeF helps students to be more productive in the learning of acid and base topic (Item 1) and ABeF is useful in the learning of acid and base topic (Item 2). Both items obtained the same percentage of strongly agreement, which is 83.08%. This means that the respondents strongly agree that the ABeF is useful for them in the learning of acid and base topic. According to Balcita, Ventayen and Palaoag [51], the system is considered useful when it saves users' time. This is confirmed by Item 3 (ABeF saves my time when I use it to learn acid and base topic) which the strongly agreement percentage is reported as 81.59%. ABeF contains QR codes that link to webpages, videos and simulation of acid base titration. The use of QR codes increases performance in learning because they prevent students from spending time on searching irrelevant information. ABeF meets my needs in the learning of acid and base topic (Item 4) gained the lowest strongly agreement percentage, which was 79.60%. This indicates that the content in ABeF needs to be more fun and interesting so that the respondents can learn the acid and base topic more easily. Lastly, the overall mean score for usefulness was 3.82 (SD = 0.39). This shows that the usability of ABeF in terms of usefulness has a mean score at high level interpretation [40].

Satisfaction of ABeF

In this study, the usability questionnaire was used to identify satisfaction of student teachers towards the ABeF through five items. Table XII shows the distribution of item agreement scales for the satisfaction of ABeF.

Table XII

Distribution of Item Agreement Scales for the Satisfaction of ABeF

No	Item	Agreement Scale Frequency (%)			
		1	2	3	4
1	I am satisfied with ABeF.	0 (0.00%)	0 (0.00%)	33 (16.42%)	168 (83.58%)
2	ABeF is pleasant to use.	0 (0.00%)	0 (0.00%)	35 (17.41%)	166 (82.59%)
3	ABeF is fun to use.	0 (0.00%)	0 (0.00%)	33 (16.42%)	168 (83.58%)
4	I would recommend ABeF to friends.	0 (0.00%)	0 (0.00%)	30 (14.93%)	171 (85.07%)
5	ABeF works the way I want it to work.	0 (0.00%)	0 (0.00%)	35 (17.41%)	166 (82.59%)
				Mean: 3.84	
				Standard Deviation: 0.37	

According to Table XII, the findings of the study show that the respondents are satisfied with ABeF (Item 1) and ABeF is fun to use (Item 3). Both items reported the same strongly agreement percentage of 83.58%. This means that the respondents strongly agree the ABeF that contains QR codes is fun to use. The respondents were happy with ABeF, but researchers need to review the need to have it and the features that will make the system fun to use [51]. Besides, respondents strongly agree that the ABeF is pleasant to use (Item 2) and ABeF works the way they want it to work (Item 5). Both items obtained the same strongly agreement percentage of 82.59%. Users believe that e-learning systems may affect performance and worry of the system as relatively easy can trigger a positive perception of satisfaction [30]. Satisfaction has a positive and significant effect for e-learning systems. Respondents would recommend ABeF to friends (Item 4) reported the highest percentage of strongly agreement, which was 85.07%. This indicates that respondents are highly satisfied with the ABeF. Lastly, the overall mean score was 3.84 (SD = 0.37). This shows that the usability of ABeF in terms of satisfaction has a mean score at high level interpretation [40].

Ease of Use of ABeF

In this study, ease of use of the digital flashcard was investigated through five items in the usability questionnaire. Table XIII shows the distribution of item agreement scales for the ease of use of ABeF. According to Table XIII, the findings of the study show the ABeF is easy to use (Item 1) and ABeF is simple to use (Item 2). Both items obtained the same strongly agreement percentage of 85.57%. This shows that the design of ABeF is simple to use and respondents can use the ABeF that contains QR codes easily. According to Law and So [52], one of the reasons to use QR codes in education is ease of use. Generating and scanning QR codes are easy for both teachers and students. This promotes the use of QR codes in education. Respondents can learn from mistakes by using ABeF (Item 4) reported the lowest percentage of strongly agreement, which was 80.10%. The quizzes in ABeF were relevant to all the acid base subtopics. Students can learn from mistakes because Quizizz will show the correct answer once they answered wrongly. Lastly, the overall mean score was 3.84 (SD = 0.37). This shows that the usability of ABeF in terms of ease of use has a mean score at high level interpretation [40].

Table XIII

Distribution of Item Agreement Scales for the Ease of Use of ABeF

No	Item	Agreement Scale Frequency (%)			
		1	2	3	4
1	ABeF is easy to use.	0 (0.00%)	0 (0.00%)	29 (14.43%)	172 (85.57%)
2	ABeF is simple to use.	0 (0.00%)	0 (0.00%)	29 (14.43%)	172 (85.57%)
3	ABeF is user friendly.	0 (0.00%)	0 (0.00%)	31 (15.42%)	170 (84.58%)
4	I can learn from mistakes by using ABeF.	0 (0.00%)	0 (0.00%)	40 (19.90%)	161 (80.10%)
5	I can use ABeF successfully every time.	0 (0.00%)	0 (0.00%)	34 (16.92%)	167 (83.08%)
				Mean: 3.84 Standard Deviation: 0.37	

CONCLUSION AND IMPLICATIONS

The purposes of this study are to develop the ABeF, identify the content validity and usability of ABeF in terms of usefulness, satisfaction and ease of use from the perspective of student teachers. The result shows that the ABeF had a very good content validity of 1.00. In addition, the usability of ABeF in terms of usefulness, satisfaction and ease of use obtained overall mean scores of 3.82 (SD = 0.39), 3.84 (SD = 0.37) and 3.84 (SD = 0.37), respectively. In conclusion, ABeF has a high content validity value as well as mean values of usability. This shows that the ABeF can be used by the form four Chemistry students in learning the acid and base topic.

There are several implications resulting from the development of ABeF. Chemistry teachers can teach acid and base topic in a more interesting way by using ABeF. ABeF provides a great way for teachers to present, teach and introduce new concepts to the students. ABeF also provides ideas to student teachers to design various teaching materials for Chemistry topics as a preparation to teach Chemistry in a more creative way. Besides, ABeF is useful for visual learners, teachers can help visual style students easily in their studies. ABeF also presents information in a clear and simple way so that acid and base concepts are easily understood by the students. ABeF pictures clear photographic images with important concepts, hence teachers can help the students on learning and revising the contents in acid and base topic easily by using ABeF.

Besides, form four Chemistry students can learn acid and base topic better with the help of ABeF that can be visualized and touched. The students are struggling to understand acid and base topic as it is too difficult, and teachers are having challenges delivering the concepts. The lack of learning aids and unfamiliar language [12] make acid and base topic separated from real life. ABeF can help the students by showing important key points, interesting videos, and simulation of acid-base titration. Students can learn more about acid and base topic through video files, simulation of acid-base titration, web pages and quizzes directly by scanning the QR codes in ABeF. ABeF promotes studying through active recall [20], which is one of the practices through which the brain learns most effectively. Students are able to involve themselves more frequently in the class activities during teaching and facilitating sessions. Finally, students can also do a quick revision and remember the content easily by using the ABeF.

This research was limited to the acid and base topic. Salt topic is excluded in ABeF because salt is considered as another topic after students have mastered acid and base topic. Researcher recommends future researchers to include the salt topic for the further research. Besides, this research was limited to investigate the student teachers' perception on the usability of ABeF through a questionnaire. As a suggestion for further research, researcher recommends evaluating the effectiveness of ABeF through experimental research. This research can be done by establishing treatment group and control group in the secondary school. The treatment group is a group of students who will learn the topic of acid and base using ABeF, while the control group is a group of students who will learn the topic of acid and base using the traditional way. Then, researcher can evaluate the effectiveness of the ABeF through the differences in students' achievement from both groups. With this research, the effectiveness of the ABeF can be identified rather than just perception study. The ABeF only contains QR codes, thus, researcher suggests future researchers to involve Augmented Reality (AR) to enhance the visualization of the acid and base concepts. By overcoming all the constrains faced by this study, the future research on the implementation of digital flashcards is hoped to enhance the teaching and learning of abstract chemistry concepts in the secondary schools.

ACKNOWLEDGEMENTS

The authors would like to thank all the respondents who involved in the study, especially lecturers and all student teachers from Bachelor of Education (Chemistry) program for the batch of September 2017/2018.

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