

Development of Digital Laboratory-based Augmented Reality

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Abstract. Media laboratories have limited space, so they cannot accommodate a lot of information. Manual learning media requires ample and static space so that it needs to be converted into a Digital-based Laboratory. This research was conducted at the Media Laboratory of the PPKn Study Program, Teaching and Education Faculty, PGRI Yogyakarta University. This research uses ADDIE stages, namely Analysis, Design, Development, Implementation, and Evaluation. The focus of this research is to develop media in the Digital Laboratory using Augmented Reality. This research involved material experts, media experts, and students in reviewing the media that had been made. Based on the research results, Augmented Reality is done by making a poster that is attached with a barcode connected to images, videos, materials, and evaluations—making Augmented Reality using the Zapworks program. This study has a feasibility of 82.13, with excellent and feasible criteria. The analysis is carried out by observing and interviewing problems that require solutions. Design is done by designing learning media, development by making several learning elements such as materials, presentations, visual images, android programs, and evaluation. It is making Augmented Reality using the Zapworks program. The implementation stage is by implementing the learning media in the Learning Media Laboratory and the evaluation stage, which evaluates the media that has been made. Recommendations for further research, of course, need to be developed again for mockups and dioramas, and other media in the Laboratory.

KEYWORDS: LABORATORY, ANDROID, MEDIA

INTRODUCTION

The Laboratory has an essential role for an educational institution in increasing the competence of graduates. Students can improve their knowledge by utilizing laboratories to create materials, explain discussions, and utilize learning media in the Laboratory. The Laboratory is also one of the assessment components in accreditation with indicators of usefulness in courses and student visits.

The Laboratory is a place to carry out various experiments which are equipped with adequate equipment. Laboratories in social sciences are defined as places that provide visual and audiovisual displays to provide additional knowledge. Laboratories are divided into several types. The first type is an essential laboratory located at the education level and managed by the internal school; the second type is a laboratory located in Higher Education and serves student education. The third type is a remarkable scientific laboratory managed by the Study Program and serves the research activities of students and lecturers. The last type is an integrated laboratory in a university study center that supports research activities and community service activities [1].

In reality, students rarely visit laboratories, especially visual-based laboratories, both two-dimensional and three-dimensional. This is caused by several things, including material in static laboratories, rarely updating the data,

changing old media even for years, media sometimes being irrelevant to the material being taught, and not using digital media. Laboratories usually have a narrow space, which creates a dilemma between adding media and reducing existing media.

Media development in the laboratory can use better techniques than manual techniques [2]. The media used can be game-based or Android-based. Learning in android-based laboratories can use mind mapping techniques. The development of the use of digital technology currently is a demand for improving the learning process [3].

One solution to many problems regarding laboratory management is developing a digital laboratory using Augmented Reality. This method can be used as an alternative to developing digital-based media that can present audiovisuals, images, materials, and evaluation links by scanning images with a mobile phone [4]. The definition of digital is the process of changing media from print, video, or audio to digital, to facilitate document archiving into an integrated digital form. [5]. The paper form can be made into *jpeg*. format, audio in *mp3*. format, while video in *mp4*. format.

Augmented Reality has been developed in the field of natural sciences [6], architecture [7], mechanics [8], physical education [9], health [10] [11], aerospace education [12]. In journals from 1999 to 2018 about Augmented Reality, its use is more on interactive learning[13]. Augmented Reality-based media is rapidly developing and showing an increasing trend [14]. In 2017 it increased to 4119 articles, 2018 increased to 5,037, in 2019, it increased again to 5,883 articles, and in mid-2020 alone, it had reached 3,721[15]. The advantages of interactive technology do not discuss the Development of Augmented Reality-based laboratories in various studies. Augmented Reality's advantages are meaningless if the curriculum does not support it, lack of programming skills and teacher motivation to use this technology [16]. Therefore it is necessary to start Augmented Reality technology in learning, especially integration with laboratories.

Augmented Reality (AR) is a technological invention that can present the virtual world in the real world in digital form. The form of the virtual world can be seen using two-dimensional and three-dimensional technological tools. *Augmented Reality* in Indonesian is also called "Augmented Reality" to add the virtual world to real-world reality. Augmented Reality programs are widely used in various fields, including health, military, technology, and education [5]. Technology *Augmented Reality* combined with equipment can make it easier to access these dimensional objects using a mobile phone, camera, webcam, or computer [17]. In developing *Augmented Reality*, there are two methods: *Augmented Reality marker* used for positional markers to create in the virtual world. The second method is *markerless Augmented Reality*. In this method, to display virtual reality, it is no longer using markers so that the resulting virtual world will immediately be able to come out automatically(Yildiz, 2018).

Augmented Reality is currently the only rapid Development for use in various fields of industry and education [19]. *Augmented reality* provides a new discourse for students to get two-dimensional and three-dimensional learning media. Students can learn various lessons using cell phones and display the reality of learning in class[20]. *Augment Reality* not only can it present the virtual world to increase knowledge. Augmented Reality can also be designed to change the affective side of students, such as motivation [21], and be used as anti-corruption education [22]. *Augmented Reality* is sometimes juxtaposed with *virtual reality* [23]. On *virtual reality*, are more likely to display a more authentic dimension using three-dimensional techniques so that the user can feel the sensation of entering the dimension created by *virtual reality*. In various studies, it is stated that both of them have a significant share in learning, *virtual reality* is more inclined to immersive learning meanwhile *Augmented Reality* is more likely to be in the cognitive areas that develop hearing [24] [25] [26].

In novelty's research, it is the development of a digital laboratory based on Augmented Reality integrated with learning by displaying audiovisuals, images, materials, and evaluation tests that can be accessed in one image. The media is made dynamic and portable so that it can be replaced with the material being delivered. The linkage of broadcast media in the laboratory and learning materials is expected to increase the frequency of student visits to the Laboratory, increase student knowledge, and increase the usefulness of the Laboratory in the learning process.

Identification of problems faced by laboratory managers and study programs, among others (1) Media broadcast in the Laboratory is static, replacement is carried out for years so that it is tedious for students, (2) The laboratory area is narrow, so it can no longer accommodate new media; (3) When receiving visits from schools, many were busy taking notes so that it seemed ineffective; (4) Laboratory broadcast materials are tedious, because they are not integrated with video, visuals, and materials; (5) The laboratory does not have a lot of media in accordance with the themes taught by several lecturers; (6) Lack of intensity of student visits in the laboratory, resulting in less utilization of the laboratory; and (7) The integration of courses has not been maximized, which is adjusted to the courses in the Study Program. The problem that will be studied in this research is how to develop a digital laboratory based on augmented reality.

METHOD

This research was conducted at the Media Laboratory of the Pancasila and Citizenship Education Undergraduate Program (PPKn), Faculty of Teacher Training and Education, PGRI University Yogyakarta. The research location is at PGRI I streets No. 117 Sonosewu Poor Bantul Yogyakarta. This research was conducted from January 2021 to May 2021.

The method used in this study uses development research using the ADDIE stages consisting of Analysis, Development, Design, Implementation, and Evaluation. This development stage is the stage of the Dick and Carry Model. The study used primary and secondary data. Primary data were obtained from data directly obtained in the field consisting of 26 people, namely one Head of the Undergraduate Program, two reviewers, laboratory managers, two user lecturers and twenty-two students. And secondary data are data obtained from previous research journals and literature following the study and supporting literature on Augmented Reality. This study uses several research data collection techniques, namely observation, questionnaires, interviews, and documentation

Data examination was carried out using validation, namely with the validity of media designs carried out by media experts with Information Technology disciplines and with the validity of media content carried out by learning experts. The validation instrument uses a Linkert scale consisting of five choices that are quantified. Each choice gets a score as an instrument assessment. There are 10 instruments, each of which is different for media experts, content experts, and students who use augmented reality programs. The validity of the instrument by media and content experts is used as a policy to revise or not the media that has been made, while the instrument for lecturers in implementing learning media is used to determine the feasibility of the media being tested. The formula for the percentage can be seen in formula (1) below:

The review results based on the predetermined instruments are then presented and matched with **TABLE 1**.

TABLE 1. Criteria for instruments

Score	Criteria
81-100%	Very good worthy / very valid / does not need to be revised
61-80%	Good/proper / does not need to be revised
41-60%	Good enough / not feasible / not valid / needs to be revised
21-40%	Not good is not feasible/invalid / needs to be revised
<= 20	Very poor / not feasible / very invalid / needs to be revised

DISCUSSION

Media Laboratory of the Pancasila and Citizenship Education Undergraduate Program (PPKn), Faculty of Teacher Training and Education, PGRI University Yogyakarta, has an area of 9 x 7 square meters. The PPKn Media Laboratory contains mockups, student learning media, displays, various shows, books, and learning compact disks. The Laboratory is also an amplifier for Multicultural Education, Mass Communication, Learning Media, Learning Media Innovation, Learning Models, and Classroom Action Research.

Based on these observations and interviews, there are several findings, including:

1. The learning media room has a narrow space so that the room cannot accommodate the growing media.
2. The materials in the media space cannot be used to support some learning because the nature of the media in the media space is static and not updated.
3. The materials taught related to learning media are sometimes not relevant to the learning material being discussed.
4. Lack of ability of lecturers to make learning media that can support learning in media laboratories.
5. Lack of visits to the PPKn Media Laboratory to interact in learning.

Based on the condition of the PPKn Media Laboratory which has broad weaknesses and lacks integration with learning. It was decided to create a Digital Laboratory using the Augmented Reality program. This program was chosen because with small media, Augmented Reality can be linked with various other information to provide a

comprehensive picture in the form of text, images, videos, programs, and evaluations and by only using barcodes to access all information needed by users.

In the development of this media, steps are arranged to create media that will be integrated with the Civics Laboratory. The steps for developing this media use the ADDIE stages, which consist of Analysis, Design, Development, Implementation, and Evaluation. In detail, Digital Media Development using Augmented Reality is as follows:

Analysis Stage

The analysis phase begins by conducting preliminary observations in the PPKn media laboratory, Faculty of Teacher Training and Education, PGRI University Yogyakarta. Various findings obtained based on observations include (1) the narrow space of the Laboratory, so that the media cannot be accommodated from year to year; (2) the lack of use of media laboratories as supporting learning materials, due to their lack of relevance to the material being taught; (3) the learning media installed in the Laboratory is static so that it cannot be replaced continuously and contains the learning being taught by the lecturer concerned.

Design Stage

Based on the analysis of needs in the early stages, learning media will be created that store a lot of information for users that can be accessed online. Students only point their mobile phones towards the media attached to the acrylic in the laboratory room to get extensive information in learning materials, photos, videos, program applications, and evaluations.

Storyboard early on in media creation using a PowerPoint as an initial framework for media description. Media is created using the Photoshop program. The learning media in the form of a display is equipped with a barcode. That has been programmed using Zapworks. The barcode contains a code to access other information on the media by installing the Zipar program on your mobile.

The learning media used today is about the Youth Pledge. The form of the media that has been made contains broadcast material about the Youth Pledge. Which contains information about the incident and its characters. The form of media for Augmented Reality is as shown in **FIGURE 1** follows:



FIGURE 1. Learning Media

The initial design of the learning media in **FIGURE 1** was installed with a barcode that was connected to online learning materials. Mobile phones that have been installed with the Zipar program can scan barcodes so that the existing impressions turn into several items on the mobile phone automatically, namely the appearance of photos, videos and photo albums containing a collection of photos during the Youth Pledge.

The video that appears automatically on the mobile phone can be enlarged so that the video about content can fill the mobile phone screen. In explaining the exposure, the video is equipped with learning material in the form of a WordPress presentation so that users can automatically download the material. WordPress is also equipped with an android program to install it and learn the program application interactively. The digital Laboratory is also equipped with an evaluation. The Laboratory and the lecturer concerned can check online users who have studied the material and know their ability scores automatically. It is hoped that visitors or users will no longer write material but only download the material, thereby reducing writing activity. The strengthening of learning in photos, videos,

materials, applications, and evaluations is deemed sufficient to broaden user knowledge about the material being accessed.

Development Stage

The development stage is the stage of realization of the media that has been created. In the initial design, learning material was designed in an A3 poster with the material. The next step is to collect and connect the media with the Zipar program to obtain a barcode. The design layout for Augmented Reality, which contains three elements, namely photos, videos, and photo albums, is arranged in **FIGURE 2** as follows:

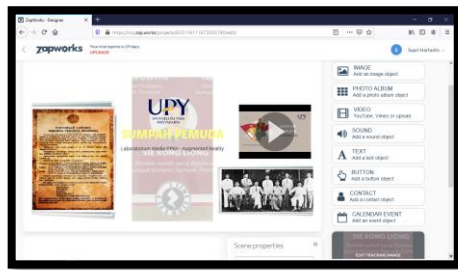


FIGURE 2. The layout of Augmented Reality

In the layout at Zapworks, several media were installed to explain the posters that were made. In the design menu, the album and video menu is selected. Several pictures of past photos related to the material incident on October 28th, 1928, are attached to the album menu. The second album is a material script made by youth associations in ancient times. Another medium that complements the Augmented Reality program is video. The video posted is a self-edited video consisting of an explanation of the Youth Pledge. If the video link is selected, it will link to the Youtube program.

Videos that are uploaded on YouTube are recorded by themselves by combining sound, images, and back sound. Voices are recorded using voice records and combined using the Filmora program. The video is then linked to the main program in Augmented Reality in the form of a copy link. The video display of the can be seen in **FIGURE 3** below:



FIGURE 3. Video access connected to Augmented Reality

The material can be downloaded automatically so can get the material quickly and no longer use a writing system that requires a long time. The form of material that is connected to the Augmented Reality program is as shown in **FIGURE 4** as follows:

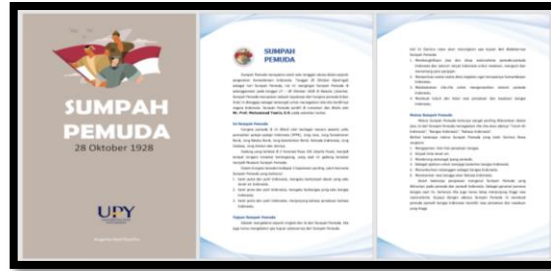


FIGURE 4. Access Learning Materials that are connected to Augmented Reality

The digital laboratory program uses Augmented Reality equipped with presentation media, namely the PowerPoint program. The technique of making presentations uses interactive exposure so that users can directly interact by pressing the menus that have been provided. The menus and themes are made following the theme. The theme is equipped with a sound background and is equipped with navigation to make it easier for users to learn it. The presentation media can be accessed at www.bit.ly/sumpahpemudapresentasi. The presentation form can be seen in **FIGURE 5** below:



FIGURE 5. Access presentations connected to Augmented Reality

One of the remarkable things in this study is Augmented Reality digital media with the Android program. The android program that is made accommodates students and users who cannot be separated from their mobile phones. The Android program is made with an interactive system and menu choices that enrich knowledge about the Youth Pledge. The program is equipped with material exposures, videos, photos, and interactive evaluations. Android media can be accessed on www.bit.ly/androidsumpahpemuda, and can be seen in **FIGURE 6** below.



FIGURE 6. Access the connected Android Application with Augmented Reality

The android program can be downloaded and installed to study the material by using the mobile phone. The program's navigation is made with a menu link system and is designed using vector-based images. Menus are made simply and linked into sub-material, photos, videos, and evaluations. Navigation on each slide makes it easy for users to select the menus that have been provided.

The Android program on the material has been equipped with an interactive digital evaluation, but this is still lacking because it cannot detect the evaluation results online. Laboratory researchers and managers can monitor their mastery of the material by providing online evaluations with the help of google forms. The link from the online

evaluation is at www.bit.ly/sumpahpemudasol. After the user reads the material that has been given, an online evaluation is held. The evaluation is tabulated in excel form to reduce the work of the media designer to calculate manually because everything can be presented in the form of an Excel program, as shown in **FIGURE 7** below.



FIGURE 7. Evaluation connected to Augmented Reality

At the material and media development stage, several parties reviewed the material and media layout. The material review was carried out by material experts, namely Yitno Pringgowijoyo, SH., MH as the leader of the Pancasila and Citizenship courses and being the Head of the PPKn Study Program. The review is carried out using an instrument that has been prepared by giving a score based on the Linkert scale and tabulated in the form of the following exposure results:

TABLE 2. Results of Validation of Learning Materials by Validators

No.	Indicators	Score
1	Content of the Material	4
2	Source Material	3
3	Grammar Meets EYD	4
4	Material Illustration	4
5	Material Support Elements	3
6	Suitability of Material with Augmented Reality	4
7	Use of Material in Blended Learning	4
8	The material in the Video	3
9	Material in Android	5
10	The material in the Presentation	4
Average		76%

Source: Results of Material Validator Instruments

The instrument results produce a percentage of 76%, which means that it is in the feasible category and does not need to be revised. Even though the criteria are not revised, it is necessary to improve the condition of the weak instruments, namely the need to include material sources, complete supporting material, and improve material in the form of videos. The input is used as a guideline for revising the media.

Besides being validated by material experts, this media is also validated by learning media experts, especially digital media. Validation was carried out by experts from the Faculty of Science and Technology. Based on the instruments that have been prepared, the results of media validation are as follows:

TABLE 3. Results of the Validation of Learning Media Design by the Validator

No.	Indicators	Score
1	Digital Media Layout	5
2	<i>Blended Learning</i>	5
3	Barcode access	4
4	Visual Access	4

5	Audio Access	4
6	Access Material	4
7	Video Access	5
8	Access Android Programs	5
9	Access Evaluation	3
10	Ease of Information between Materials	4
Average		86%

Source: Media Validator Questionnaire Results

Based on the media-making instrument related to Augmented Reality, a score of 86% was obtained, which is in the excellent category and does not need to be revised. Based on this instrument, although it does not need to be revised, it is still addressed in the evaluation section, which received a low score before it is implemented.

Implementation Stage

At this stage, the digital learning media that has been created is then pasted in the Media Laboratory to be seen by users. To provide feedback to digital media designers, questionnaires were distributed to users who incidentally were PPKn students. The students involved in filling out the questionnaire were PPKn students who visited the laboratory.

Media laboratory users try the accessibility of using digital learning media. The number of students visiting the Media Laboratory is 22 people. The questionnaire was given online via a google form to simplify the process of scoring and writing names. The following are the results of a questionnaire about the application of Augmented Reality. The results of the questionnaire can be seen in **TABLE 3** below:

TABLE 4. Questionnaire Results for Digital Augmented Reality Laboratory Users

No.	Indicators	Score
1	Media Innovation	4.2
2	Ease of Media Access	3.5
3	<i>Blended Learning</i>	4.8
4	Navigation	4.2
5	Material Conformity	4.4
6	Increase Motivation	3.8
7	Solving Media Laboratory Problems	4.1
8	Can Be Accessed Online	4.3
9	Visual, Audio, Video Quality	4.4
10	Improve Material Mastery	4.5
Average		84.4%

Source: User Instrument Results

Based on the results of the questionnaire, the media category amounted to 84.4 percent. The media is in the category "Very good feasible / very valid / does not need to be revised." Based on the questionnaire results, it is necessary to improve the learning material that always increases student motivation.

Evaluation Phase

Based on evaluating making a Media Laboratory using Augmented Reality, it is necessary to improve it based on input from media experts, material experts, and students as users. The evaluation is based on the inputs that have been obtained for improvement in making media for other digital laboratories. The evaluation obtained is then followed up by improving programs that focus on the evaluation system, material supporting elements, video material, and the sustainability of the Digital Laboratory system.

RESULT

The Development of a Digital Laboratory based on Augmented Reality begins with a needs analysis. This analysis is a strategy to find problems that occur, so it requires a solution. Alternative solutions to these problems are then discussed with the research area to be used as material to develop in research. A Digital Laboratory was developed in the Faculty of Teacher Training and Education PPKn Study Program using the ADDIE model. Augmented Reality-based media development is based on analysis, design, development, implementation, and Evaluation. This stage also involves media experts, material experts, and users as materials for revising and evaluating the media that has been created.

Augmented Reality-based media development begins with a needs analysis at the analysis stage of the ADDIE model. The needs analysis is carried out by conducting preliminary observations on the conditions of the Media Laboratory in the PPKn Study Program. This analysis is also corroborated by interviews with the Head of the PPKn Study Program, Laboratory Managers, and laboratory user students. Based on this needs analysis, several problems require solutions, among others:

1. Media broadcast in the Laboratory is static; replacement is carried out for years, so it is tedious for students.
2. The laboratory area is narrow, so it can no longer accommodate new media.
3. When they get visits from schools, many are busy taking notes so they seem ineffective.
4. Laboratory broadcast material is tedious because it is not integrated with videos, visuals, and materials.
5. The Laboratory does not have much media by the themes taught by several lecturers.
6. Lack of intensity of student visits to the Laboratory, so that laboratory utilization is less.
7. The integration of courses has not been maximally maximized, which is adjusted to the courses in the Study Program.

The main problem has been selected, namely, the need for media development based on Augmented Reality to provide a perfect solution for the space in the Media Laboratory, and the second problem, integrating learning into the Media Laboratory, so that visits the Laboratory increase. The two main problems arise in the analysis stage.

At the Design stage, various elements needed to make learning media that have been designed are prepared. The design of the media is in the form of media exposure that can be installed in the Laboratory but can be replaced quickly. One solution that was taken was to use a double acrylic poster size A3, which is permanently affixed to the laboratory wall but can be replaced easily because a retaining nut can be turned to remove the media that has been made. Visual images of the chosen theme began to be collected. The viewing material includes visual images, videos, and text. In designing the design, a storyboard is used, which uses the PowerPoint tool for the initial design. This program can give a quick overview of the type of font, layout, audio filling, and coloring. Vector-type images are used in the visual process, while the coloring technique uses pallet color, while audio is downloaded using the *juicemp3*. program.

The next stage in development at this stage which is made the first time is learning material. The learning materials are obtained from various sources, which are then made as teaching materials in material layout designs in pdf form. The development of the following learning element is a presentation using a PowerPoint as the basis for its manufacture. Powerpoint is very flexible and easy to operate by all groups, so this program was chosen to make presentation shows.

Another medium that is made is video. In video media, it is made by going through several stages. The first stage is to find material by downloading images and videos, and the next stage is to create an exposure scenario. The next stage is making a video by combining images, video, and sound with the help of the Filmora program. The final result of this program is a learning video with the extension mp4. The design stage for other learning elements is creating a blog containing all learning information as documentation. This learning documentation is following the material being taught. In the material archive, at the end of the presentation, it is connected with all

learning elements in learning materials, learning presentations, learning android programs, and learning evaluations.

One of the new things that are being prepared is the creation of an Android program. This program was initiated by online learning and the use of the hobby of using mobile phones. The android program is made with an apk extension and can be downloaded by users and learned interactively. Android application program files about content can be downloaded with the link. The Android-based material contains learning material, instructional videos, visual learning, and learning evaluation. This program is expected to bridge the needs of users who prefer interactive learning based on smartphones.

The learning poster is then created as the primary material for digital learning using Augmented Reality. Posters are made using A3 size graphics and text; then, they are permanently installed on the acrylic display board on the wall. The acrylic board consists of two layers and is reinforced by a nut that can be easily removed to replace the media quickly. Barcodes are installed on the broadcast media to access other online learning materials.

It is making Augmented Reality using the help of a program, namely Zapworks. This program is available online and is relatively easy to operate. This program can design patterns that contain sound, visual images, albums, links, bottoms, and videos. This program requires a downloadable scan tool called zipar. Zipar then scans the barcode and connects the poster with other online media.

Stepping to the next stage is implementation. This stage is installing media in the Laboratory as a forerunner to making a digital laboratory. Visitors who come to the Laboratory are then asked to try Augmented Reality-based learning media and fill out questionnaires online to be easily tabulated. Students who visit the Laboratory come from various semesters, considering that there were not many students present on campus during the pandemic.

The last stage is evaluation; based on the scores from media experts and material experts. The results show that the learning media are feasible and do not need to be revised. Even though the results are decent, there need to be some improvements made by looking at the lowest score. This evaluation is intended to improve the broadcast media for further Augmented Reality.

CONCLUSION

Based on the research results, it can be concluded that the Development of a Digital Laboratory based on Augmented Reality can be built by phasing it, starting with a blindness analysis. The stages are carried out using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation. The analysis is carried out by observing and interviewing problems that require solutions. Design is done by designing learning media, development by making several learning elements such as materials, presentations, visual images, android programs, and evaluation. It is making Augmented Reality using the Zapworks program. The implementation stage is by implementing the learning media in the Learning Media Laboratory and the evaluation stage, which evaluates the media that has been made.

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