



## Gema Cow-Pu: Development of Mathematical Crossword Puzzle Learning Media on Students' Critical Thinking Ability:

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### Abstract

Critical personality is a skill that must be possessed in order to survive in the global competition of 21st century society. Given that critical thinking education is an important part of human life, innovations must be carried out to foster students' critical thinking. One of the studies he conducted was the innovation of crossword learning media (GEMA COW-PU). In this study, the development of learning media for mathematical crossword puzzles (Gema Cow-Pu) was carried out on Geometry material at YALC Pasuruan Middle School and tested the learning media on students' critical thinking skills. This is intended to determine its validity and practicality. The specialty of this research is research and development based on the Borg n Gall development model. The research subjects were ten students of class VIII. The instruments used were validation sheets, teacher and student response questionnaires, and student learning outcomes tests. The results showed that the relevance score of Gema Cow-Pu learning media with students' critical thinking skills was in the very valid category with an average score of 89.75 percent, and Practical with a percentage of 95.3%. This shows that the Gema Cow-Pu learning media meets valid and practical criteria so that it can help students' critical thinking skills in learning.

**Keywords** — Building Flat Sided Spaces, Critical Thinking, Crossword Puzzles, Mathematics.

### Introduction

Critical personality is a skill that must be possessed in order to survive in the global competition of 21st century society. Quality education is an effort to face education in the 5.0 era, which is expected to continue to develop science (Fukuda, 2020; Inganah et al., 2023). The quality of teaching for educators can certainly be improved through innovations such as methods and media for developing student skills (Baiduri et al., 2020; Darmayanti, et al., 2022). Thinking skills that are taught and mastered in schools are higher order thinking skills, critical thinking (Arisoy & Aybek, 2021; Meirbekov et al., 2022). Given that critical thinking education is an important part of human life, innovations must be made to foster students' critical thinking.

In fact, there are still many educators who do not use learning resources, and limited media facilities contribute to low interest in learning and developing students' critical thinking skills, which is very difficult (Alpusari et al., 2020; Güner & Gökçe, 2021; Nugroho et al., 2018). According to initial observations during pre-mathematics learning, especially on flat sided geometric material, the problems of class VIII students at the Assyfa Learning Center (YALC) Pasuruan Foundation were that in the process of providing teaching materials teachers often used the lecture method, and media that invited students was widely used. Proactively ask questions and think critically to solve problems that require alternatives. It allows students to actively participate and develop critical thinking skills, but is also a fun way to learn (Morozova et al., 2022; Siburian et al., 2019). The lecture method makes students passive and does not make them think, so restrictions are needed and educators must provide many opportunities to actively develop their skills (Haftador et al., 2021; Muwahiddah et al., 2019). Developed in class. If students are not given the opportunity to express their thoughts, this will affect the development of their critical

thinking skills.

To make it easier for teachers to help develop students' critical thinking skills, a teaching material is needed, where teachers can use learning media. Learning media is one tool that is believed to help in learning. In addition, the use of learning media is very important to achieve learning goals and is something that can help teachers and students (Asbari et al., 2020; McAdoo et al., 2019; Oracion & Abina, 2021). Learning media can help equate students' perceptions of a material so that the learning outcomes are maximized (Delviana et al., 2021; Puspitarini & Hanif, 2019; Rachmavita, 2020). The use of media in learning in the classroom according to its use can help students express various abstract mathematical concepts into reality so that the motivation and enthusiasm of students in learning mathematics can grow (Alphonse & Mwantimwa, 2019; Hasanah, Syaifuddin, et al., 2022; Song & Bonk, 2016). considered even as a spare time filler. In fact, if examined carefully, well-managed math games will be able to help develop intellectuality, be able to assist students in developing students' critical thinking skills, hone various skills, especially in solving problems and transferring material, as well as add insight into the procedures for learning mathematics.

The way students learn mathematics will affect their understanding of the various concepts contained in the game which can increase because of the entertainment side of the game which can motivate students to learn (Cardinot et al., 2022; Danilovic & de Voogt, 2021; Scott et al., 2022). One of the media used in learning, especially learning mathematics is the media of crossword puzzles (TTS) mathematics. TTS Mathematics is an alternative that helps maximize students' potential and makes them more active and creative in learning mathematics (Maria et al., 2021). The use of TTS media increases students' motivation and enthusiasm for learning vocabulary, facilitates understanding of material, stimulates reasoning and knowledge, and makes learning very memorable, and makes it an unforgettable experience (Rohmawati & Suhardi, 2022; Saputra, 2019). Number crossword games can be used very effectively to improve students' learning success and critical thinking.

The results of other relevant studies which show that crossword games have a very good effect on learning both in terms of results, sports, and students' thinking methods consisting of crosswords media can be used as set recreation-based media. so as to increase success and sports in learning (Bar & Otterbring, 2021). In addition, learning outcomes at the same count also show that an increase in math games in the form of crossword puzzles with valid classes can be used, types of abilities in dealing with learning, and student responses to software video games in learning are in the very good category, and response to the quality of students towards TTS media also very practical (Niculescu & Ștefăniță, 2022).

The differentiator of this research that will be developed is by developing TTS learning media as an effort to develop the thinking skills of class VIII students on flat sided geometric material (calculating the length of one side of the geometric shape if the lengths of the other sides are known, looking for the area and volume of the geometric shape, elements and basic concepts related to other three-dimensional material). The questions are presented in stages starting from level 1 to level 6 with adjustments to indicators in critical thinking skills. In addition, the media that will be developed is an effort to solidify the material that has been taught in formal schools, through the medium of Crossword Puzzle Geometry Material which the researchers named the media "GEMA COW-PU".

Furthermore, with the lifestyle of math crossword puzzles whose goal is to assess the cessation of learning and repetition of material, it is able to make students obsessed with working in learning because to fill in the crossword puzzle students must master the material. In addition, GEMA COW-PU media can create lively learning, improve principles and improve learning outcomes. Based on these considerations, the aim of this study was to develop GEMA COW-PU learning media for the mathematical critical thinking skills of Grade VIII SMP students at YALCP Pasuruan which are valid, practical, and effective for use in the learning process .

## Research Method

This type of applied research is research and development (R&D). The design and procedure for this development research used the Borg & Gall procedure (Rohmaini et al., 2020). Developing according to the Borg & Gall process consists of 10 development steps leading to a ready-to-use final product, including: possibilities and problems, data collection, product design, design verification, design revision, product testing, product revision, and usage. Trial, product modification, and mass production. However, considering the time and cost constraints, when studying the development of GEMA COW-PU media, researchers limited it to seven steps and held intensive face-to-face meetings as shown in Figure 1 .

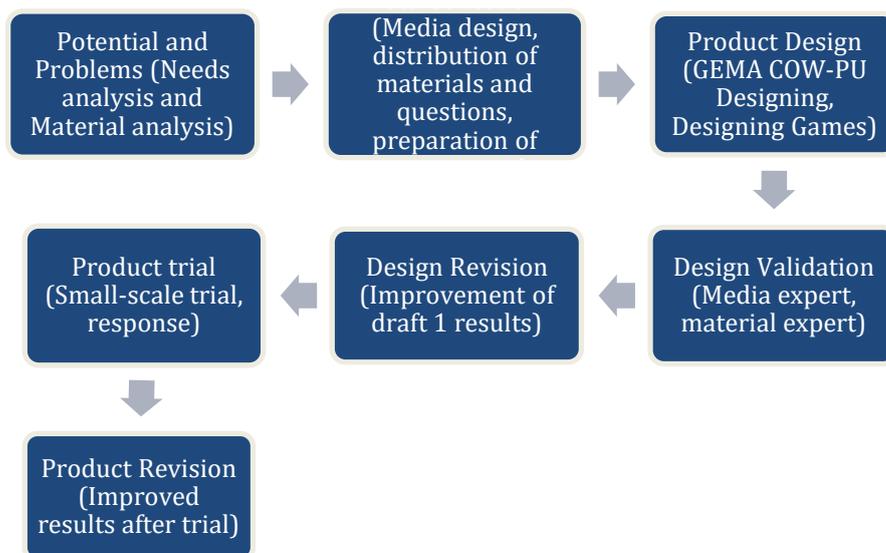


Figure 1. Stages of Borg and Gall Development Flow

Based on Figure 1, at the trial stage it is necessary to determine the subject. The subjects were class VIII students at YALC Pasuruan. Product trials consisted of media design experts and learning materials. It takes place in three stages of its professional testing by experts. Small trial of the product was then conducted with ten students randomly. Data collection means using a questionnaire. The questionnaire used was a design expert questionnaire, a material expert questionnaire to check product efficacy, and a student response questionnaire to check product practicality. The data analysis technique used is a qualitative and quantitative descriptive analysis technique. Qualitative descriptive analysis was carried out by grouping information from qualitative data in the form of input, criticism, and suggestions for improvement contained in the questionnaire. This qualitative descriptive analysis technique is used to process the data obtained from expert judgment in the form of suggestions and comments for improving the media of the mathematical crossword game. Quantitative descriptive analysis technique is carried out by analyzing quantitative data in the form of numbers obtained from the questionnaire. The formula used to analyze the results of the questionnaire is the ideal percentage. That is, the resulting score is divided by the ideal maximum score multiplied by 100%. The results of the calculation of the resulting presentation is determined by the level of product feasibility. Product certification criteria (Darmayanti, et al., 2022).

## Results and Discussion

In development research, starting from the GEMA COW-PU crossword puzzle to material for geometric operations, namely geometric elements, properties, diagonals, areas, and spatial volumes, the results developed by researchers in the form of game media will be explained in step next.

### Data collection

Data was collected during the needs analysis and materials analysis stages. This research requires analysis by conducting interviews and observations to find problems in this school. In this case YALC Pasuruan was chosen. Most students experience boredom in learning, especially in terms of remembering math subjects which are identical to the many formulas making students less interested in learning them. Furthermore, students also experience difficulties in drawing conclusions when faced with various arguments in solving mathematical problems. Based on the problems found so that: a) needs analysis: it is necessary to have a tool in the form of learning media, which is interesting, fun, capable of developing students' critical thinking skills in learning geometry material, in which there are consistent problem practice activities; b) material analysis: The data required includes firstly media design such as shapes, materials, and colors, secondly, distribution of math crossword puzzle material according to class, thirdly, questionnaires for material experts, media design experts, and students. Including making a research tool in the form of a questionnaire. The distribution of material and questions for each level in learning with GEMA COW-PU media is shown in Figure 2 which contains indicators of critical thinking skills.

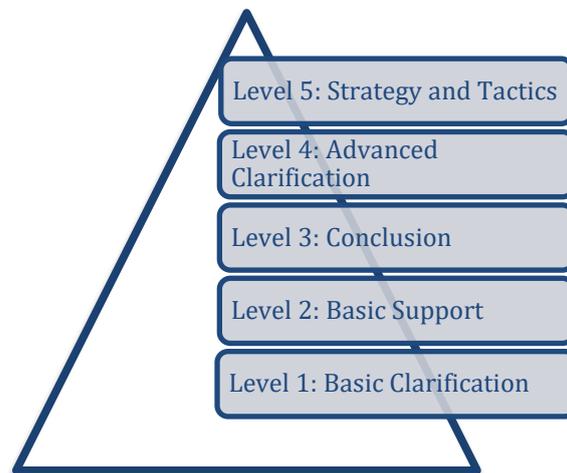


Figure 1. Materials and Questions in GEMA COW-PU Media

### Design (Design Stage)

GEMA COW-PU media was prepared as a geometry teaching material. The research design step consists of determining materials for geometry material by including five indicators of critical thinking skills : levels 1-5 (Basic Clarification, Basic Support, Conclusion, Advanced Clarification, Strategy and Tactics) (Darmayanti, Sugianto, & Muhammad, 2022), geometrical properties, calculating the length of one side unknowns, diagonal, perimeter, area, and volume of plane side shapes . Prepare reference books and other source books, scientific articles indexed at least sinta 3 related to mathematical crosswords. The next activity is designing a math crossword game. The GEMA COW-PU media design is in the form of digital media, designed with the help of the Canva application, students can download it, can fill in directly, so this media can be done online and offline, designed with code access, where students cannot continue to level 2, 3, or the next level if at the previous level the student has not been able to complete the challenges at the initial level. Like GEMA COW-PU, it is attractively designed with elegant, varied and communicative color combinations that students like. GEMA COW-PU provides information in the form of questions and diagrams about flat side shapes, contains critical thinking skills, and is arranged according to good writing.

### **Develop (Development Stage)**

The development of media in the form of the GEMA COW-PU game which is used as a visual aid in learning mathematics, especially the flat sided shapes on critical thinking skills has been validated by two experts. The two experts are teachers who teach at YALC Pasuruan. The expert is tasked with evaluating the suitability of the materials used and the playing media used, as well as the design of the GEMA COW-PU game. Validation was carried out using a validation questionnaire consisting of GEMA COW-PU Media Questionnaire Material and GEMA COW-PU Media Questionnaire Design. Evaluation results for all aspects are measured by a Likert scale. Likert scale is a collection of positive or negative statements about the assessment of an object. This principle works by determining the trajectory of a person's position on a continuum of attitudes toward objects (Vidyastuti et al., 2022).

Aspects in Figures 3 and 4 have been validated by GEMA COW-PU mathematical game design experts from both media and material aspects.

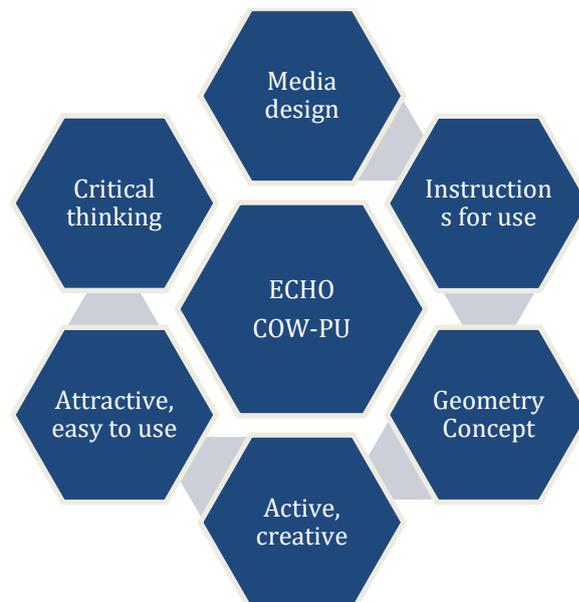


Figure 2. GEMA COW-PU Media Components (Sugianto et al., 2022)

Figure 3 is part of some of the components in the GEMA COW-PU media, in more detail the components or aspects of the media that have been validated by experts are: (a) media design according to numerical manipulation material to build flat side chambers; (b) the instructions for using GEMA COW-PU mathematics are clear; (c) does not contain an element of conceptual error; (d) Design for development; (e) Encouraging students to participate actively in learning; (f) Helping students understand the material for flat-sided shapes; (g) GEMA COW-PU math media using beautiful and attractive colors and shapes; (h) Being able to help students to develop mathematical critical thinking skills; (i) Easy to use and efficient, (j) Reusable; (k) Easy to carry anywhere; (l) GEMA COW-PU Mathematics trains students to think quickly and precisely; (m) GEMA COW-PU Math is easy to store and durable. The GEMA COW-PU media component in Figure 4 is a component of the material aspect.

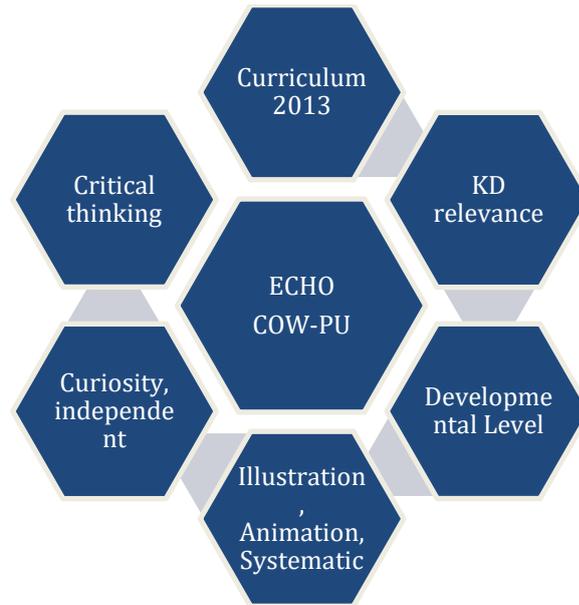


Figure 4. Material Components of GEMA COW-PU (Hasanah, In'am, et al., 2022)

Figure 4 is part of some of the components in the GEMA COW-PU media in terms of material, in more detail the components or aspects of the media that have been validated by experts are: (a) The mathematical material of GEMA COW-PU is related to Build a Flat Side Room; (b) GEMA COW-PU is related to the skills students need to master; (c) The flat sided room manipulation material presented in GEMA COW-PU varies according to the level of student development; (d) that the teaching materials comply with the curriculum requirements; (e) Illustration of functional math COW-PU GEMA; (f) GEMA COW-PU media competency includes indicators of critical thinking; (g) The material presented in each GEMA COW-PU mathematics consists of flat sided geometric material (no mixture with curved side geometrical material); (h) The material presented can arouse students' curiosity; (i) The material presented stimulates thinking about problem solving; (j) The material presented encourages independent learning; (k) encourage students to construct their own knowledge; (l) Vertical and horizontal GEMA COW-PU materials are systematically arranged.

The results of the questionnaire verification for media experts and material experts for the GEMA COW-PU Mathematical game media are described in table 1.

**Table 1.** Validation results on GEMA COW-PU media

No.	Rating Type	Aspect	Expert Validation	Score	Categories
1	Theory	ABCD EFGH IJKL	2 experts	89.4%	very good
2	Media	a, b, c, d, e, f, g, h, I, j, k, l, m	2 experts	90.1%	very good

Media design experts assess that the developed GEMA COW-PU media is very easy to use, trains fast and precise thinking, trains students' critical thinking skills, as well as other aspects of components, getting a score of 90.1 percent in the "very good" category. In addition to the validated aspects of the GEMA COW-PU media design, aspects related to the media material were also validated by experts. As for the GEMA COW-PU math game aspect which was validated by material experts with a score obtained was 89.4 percent in the "very good" category.

Meanwhile, table 1 is the conclusion from the GEMA COW-PU media validation by material and media experts.

**Table 2.** The mean results of GEMA COW-PU media validation

Rating Type	Expert Validation	Total Score	Average Score	Categories
Theory and Media	4 experts	179.5 percent	89.75	Very good and doable

Table 2. The results of design experts and material experts show that GEMA COW-PU media on students' critical thinking skills is very good and helps clarify mathematics learning, especially the concept of flat sided space with a score of 89.75 percent. This shows that the GEMA COW-PU media is very suitable when used to study flat-sided geometric material, especially to train and develop students' critical thinking skills. This finding is reinforced by [Silberman's \(2013\)](#) opinion about his GEMA COW-PU as a concept repetition strategy. The GEMA COW-PU strategy is a method for clarifying which concepts have been learned and examining aspects of the skills and knowledge acquired.

### ***Design Revision (Stage Revision)***

The GEMA COW-PU media at the design revision stage focuses more on product designs that are validated by experts, where weaknesses are identified. These weaknesses are then revised with the aim of creating a better product. If the product is invalid, it will be repaired and verified by experts. Limited product trials may be conducted if the product is deemed to be truly effective. The GEMA COW-PU media was developed from the validation results of material experts and media design experts and is classified in the "Very Doable" or "Very Good" category so no repairs are needed. Therefore, the revised GEMA COW-PU media can be carried out to the next stage, namely the trial stage.

### ***Trial (Trial Stage)***

The GEMA COW-PU media in this product test was carried out on a small or limited sample consisting of ten students at SMA YALC Pasuruan. This experiment was carried out after the validation results were verified by the validator. This stage is carried out to obtain practical teaching materials. A product is considered useful if it is not difficult to apply. The aspects of assessing student responses are ([Anjarwati et al., 2023](#)): (a) The flat sided spatial material on GEMA COW-PU media makes it easier to understand mathematical concepts; (b) Learning with GEMA COW-PU is more fun; (c) Learning with GEMA COW-PU media can train skills in critical thinking step by step at each level; (d) Learning mathematics with GEMA COW-PU makes me more active; (e) Interesting math COW-PU GEMA display; (f) Mathematical crossword puzzles help students find area and volume results easily; (g) It doesn't take long to learn how to use GEMA COW-PU; (h) Work hard on math problems with GEMA COW-PU; (i) I have the confidence to solve the flat side geometrical problem with Echo COW-PU; (j) By learning how to use GEMA COW-PU, I can teach myself; (k) Learning mathematics with GEMA COW-PU makes me happy. Table 3 is the result of a questionnaire assessing student responses to the GEMA COW-PU math game media.

**Table 3.** The results of the student response assessment questionnaire on GEMA COW-PU Media

Student	Observed aspect	Total Score	Category
10 Children	a, b, c, d, e, f, g, h, i, j, k	95.3 percent	Very Practical

Responses to a small experiment conducted by ten YALC Pasuruan students. As for suggestions from small experiments, the ten students said the GEMA COW-PU media was very interesting and very easy to understand. The overall percentage is 95.3 percent, which means that the math crossword game medium, GEMA COW-PU, is very easy to use. The use of the media is reflected in the attractive appearance of the media, the ease of using the media, and the positive changes achieved by students, increasing self-confidence, willingness to learn, and independence in learning and guiding students to develop their critical thinking skills. As can be seen from the student responses in Table 3, all of this was achieved using the GEMA COW-PU media. During the experiment, the researchers generated the COW-PU Echo, which consists of a crossword puzzle on critical thinking skills at each level with flat-sided geometric material. From math problems, ten students answered easy math crosswords. This is in line with the results of a student survey, where 93.3% said that using TTS made it easier for them to understand the concept. This result is consistent with the assertion (Sinaryati, 2022; Tambaritji & Atmawidjaja, 2020) that classrooms need to introduce concepts with real experience. Sadiyah et al., (2019) states that one of the functions of teaching tools is to make learning more concrete. Furthermore, the experimental results also show that if the criteria for good teaching materials have attractive shapes and colors and can clarify mathematical concepts, then the teaching materials developed are good according to (Mshayisa, 2020) that seen at 100%, in other words all children say that the presentation of the puzzle very interesting math crossword.

### Product Revision (Stage Product Revision)

Product revision GEMA COW-PU gaming media with a proven track record has been revised again based on product trial results. Mathematical Crossword Game Media That Has Been Tested and Revised Produces Useful Products. Mathematical crossword game media is included in the stereoscopic video media type. (Wijaksono S & Siddik, 2022) explained that 3D visual media is visible media that contains elements in the form of lines, shapes, colors, and textures. The GEMA COW-PU game media material for flat sided space construction on the critical thinking skills of grade VIII junior high school students. Below is an image of the GEMA COW-PU math media which has been tested for validity and practicality.



Figure 5. Display of GEMA COW-PU Media at level 1



Figure 6. Display of GEMA COW-PU Media at level 2

Based on the seven development achievements through the Borg & Gall model development process where the procedure described allowed this research to run smoothly and achieve the expected results. This is in accordance with the research objective, namely, to produce a product in the form of COW-PU GEMA on students' critical thinking skills on geometry material "flat sided space" which is valid and practical. This can be seen from the results. Validity questionnaire and practicality questionnaire, the validity of GEMA COW-PU mathematics in general can be seen from the artistic and material validity, as well as the utility of mathematical crossword puzzles in general. Developing GEMA COW-PU mathematics in accordance with the expectations, goals and needs of students. The GEMA COW-PU crossword test gives good and positive answers about the GEMA COW-PU in mathematics. Apart from that, the student also said that GEMA COW-PU mathematics was very interesting, motivated and facilitated students in developing critical thinking skills to be able to understand the concept of a flat sided space. The GEMA COW-PU Mathematics media is also not revised so that this media can be used to facilitate students' strengthening of the material on flat sided shapes on their critical thinking skills.

## Conclusion

The conclusions drawn from the results of research on the development of mathematical crossword puzzle media are: (a) The level of adequacy of the GEMA COW-PU media for flat sided geometrical material is said to be very reasonable; (b) The practical ability of the teaching material on the flat sided space construction of the GEMA COW-PU game media in the small group trial of 95.3 percent was very practical. This shows that the developed mathematical crossword game media is very practical, motivates students to learn, is able to develop students' critical thinking skills, and is easy to use for learning. The results of this study suggest that future researchers can collaborate on interesting math learning methods, resulting in more diverse learning, adding more experts, and better math crossword media by adding test subjects and at different mathematical abilities to improve research.

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