



# Enhancing Open and Distance Learning Materials: Validating the AFCI Model for Basic Chemistry

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**Abstract:** In this study, we present the validation of the AFCI (Analysis and Identification, Find Color, Color Composition, and Implementation) model as a problem-based approach to enhance the quality of multicolor output in open and distance learning materials. The primary objective was to evaluate the reliability and validity of the AFCI model, specifically designed to incorporate two-color separation techniques aimed at reducing costs while improving the quality of multicolor content. Our research encompassed the examination of printed modules and samples across diverse subject areas, including Basic Chemistry, Architecture, Enterprise System Design, and Teacher Profession. To establish the validity of the AFCI model, a comprehensive validation process was conducted, involving focused group discussions with experts specializing in graphic design, printing, and educational materials. The outcomes of this rigorous validation process revealed substantial validity coefficients ( $r_{\alpha}$  visibility = 0.98,  $r_{\alpha}$  attractiveness = 0.97,  $r_{\alpha}$  convenience = 0.91,  $r_{\alpha}$  emphasis = 1), affirming the model's effectiveness. Furthermore, the internal consistency of the AFCI model was confirmed with a Cronbach's Alpha coefficient of 0.86. This research significantly contributes to the realm of open and distance learning by introducing an innovative model for improving multicolor content quality. The AFCI model's successful validation underscores its potential to benefit practitioners and educators in developing high-quality teaching materials, thereby enhancing the overall learning experience in open and distance education.

**Keywords:** AFCI model; Open and distance education materials; Two-color separation; Validity and reliability

## Introduction

Universitas Terbuka (UT) has been at the forefront of open and distance learning since 1984, implementing the Distance Education (DE) system. DE is characterized by autonomous and independent learning, emphasizing the role of students in learning independently (Prasetyo et al., 2022). Consequently, educators and educational institutions provide facilitation to enable students to engage in the learning process according to their style and needs. Thus, the added value of the education process lies in the students' independent learning, utilizing learning resources and assistance provided by

the institutions. Every student has an equal opportunity to learn, without geographical limitations, health constraints, or work-related hindrances (Damianidou & Georgiadou, 2022). The primary responsibility of institutions and educators is to create a conducive atmosphere for students to learn independently and provide access to various media and learning resources.

To establish UT as a cyber-university, continuous efforts are made to enhance the quality of teaching materials, products, and services provided to students and stakeholders. UT is committed to improving the quality of learning through the utilization of technology. The printed teaching materials of UT, known as Basic

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Materials Books (*Buku Materi Pokok/BMP*), serve as the primary instructional materials, supplemented by non-printed materials such as UT Radio, UT TV, open educational resources, and online-based enrichment materials. BMP can be obtained in print form, as Digital Teaching Materials (*Bahan Ajar Digital/BAD*), or in the Virtual Reading Room (*Ruang Baca Virtual/RBV*) (Sufandi, 2022). From the students' perspective, in the context of distance learning, the learning process serves to overcome challenges using technology and limited interactions with educators. From the educators' perspective, open and distance learning focuses on effectively delivering learning materials despite not being physically present in the same location (Pakhomova et al., 2022). Most of the Distance Learning (*Pendidikan Jarak Jauh/PJJ*) students are self-directed adults (Yamashita et al., 2021). This means that they only require a minimal interest in the subject matter, as they quickly become engaged in the learning process.

The current BMP encompasses all the necessary content to achieve learning objectives and is designed for self-instructional learning, although with limited interactivity. It is supplemented with examples to facilitate understanding (Sadjati et al., 2014). The journey and development of UT's printed BMP began with A4, B4, and A5 formats. In 2019, UT started developing Interactive Teaching Materials (*Bahan Ajar Interaktif/BAI*), which are printed materials in a custom A4 format. This development has continued as UT transitions from the A5 format to the custom A4 format. These efforts aim to improve the quality of teaching materials, integrating information and communication technology (ICT) with meaningful learning experiences. Through these endeavors, students can engage in interactive learning activities, including cognitive aspects, navigation menus, and enriched substance through multimedia integrated with the Interactive BAI (Suciati et al., 2018).

One of the BMPs used for student learning, particularly for chemistry students at UT, is Basic Chemistry. The BMP PEKI4202 Basic Chemistry contains materials on Solutions, Chemical Kinetics, Chemical Equilibrium, Acid and Base Solutions, Colloids, Electrochemistry, Inorganic Chemistry, Nuclear Chemistry, and Organic Chemistry (Sumari et al., 2019). Through this BMP, students are expected to be able to explain the fundamental concepts of chemistry and apply them in the learning process. As UT students are required to engage in independent learning, the Basic Chemistry BMP needs to be presented clearly, attractively, and consistently.

The Analysis and Identification, Find Color, Color Composition, and Implementation (AFCI) model was developed in 2022 to address several issues encountered

in the format of teaching materials. Identified issues include increased production costs, inappropriate color selection using different applications, inconsistent color output, changes in meaning or content, and inefficient use of colors per page. Based on these identified issues, researchers have developed a two-color separation method to achieve multicolor quality in printed teaching materials for distance education. This method utilizes Adobe application technology, which is the industry standard and accommodates the CMYK color model used in printing today (Gooby, 2020).

This study holds substantial significance within the realm of distance education and open learning. To begin with, the explosive expansion of information and communication technologies has made distance education the primary preference for many individuals seeking higher education or professional advancement (Pandiangan, 2023). Nevertheless, a significant hindrance to distance education lies in the limited availability of top-notch learning materials. Especially in the contemporary digital age, where multimedia and visual presentations assume pivotal roles in the learning process, it is imperative for distance education to furnish high-caliber materials that are engaging, informative, and integrate effective multimedia components (Budiastra et al., 2022). Consequently, this investigation aims to formulate and verify the AFCI Model (Analysis and Identification, Find Color, Color Composition, and Implementation) for the creation of superior, colorful learning resources designed to enhance the learning experience for students engaging in distance education environments.

Furthermore, this study holds relevance within the sphere of optimizing educational resources. Educational institutions frequently turn to distance education to attain cost-effectiveness and broader reach (Sekarwinahyu et al., 2023). Through the development of two-color separation techniques for crafting educational materials, this research has the capacity to curtail the expenses associated with the production and dissemination of learning resources. Furthermore, by assessing the validity and reliability of the AFCI Model, educational establishments can ascertain that the materials generated conform to elevated quality benchmarks. Consequently, this investigation not only carries the potential to enhance the learning encounter for remote students but also constitutes a substantial contribution to endeavors aimed at attaining efficiency and efficacy in the delivery of distance-based education.

This research suggests the use of two-color separation to improve production cost efficiency and optimize the use of two-color separation in BAI components and multimedia. The AFCI model was developed specifically for A4 custom two-color

separation to address these issues. The model development involves four stages: analysis and identification of BMP components based on the identified issues, determining the appropriate colors according to printing methods, selecting color combinations, and applying the color composition format to BMP components. This model, known as AFCI (Analysis Find Color Composition and Implementing), aims to simplify print production, ensure consistent layouts and BMP colors based on predetermined color compositions, and maximize the effective use of BMP colors. It is expected to enhance the attractiveness and quality of BMP, motivating students to engage with the modules. The impact of 21st-century learning environments on student motivation has been reported to be significant (Adedokun & Carleton Parker, 2017). This highlights the potential mediating role of changes in motivation on student outcomes. The validity and reliability of the AFCI BMP are carefully evaluated to ensure the developed BMP meets the desired quality. The objectives of this study are to evaluate the validity and reliability of the AFCI BMP for two-color separation especially for Basic Chemistry, as well as Architecture and Enterprise System Design, and Teacher Profession.

## Method

The development model used in this study is divided into four stages: define, design, develop, and implement. The defined stage is a literature study, field survey for needs analysis, and printed module for problem identification. A needs analysis was carried out through interviews and a literature review. Printed module analysis was carried out by studying basic color theory in printing circles. The design phase was carried out by identifying color, find color. The development phase was carried out by composing color, selecting formats, and designing the initial. The implementation using color compositions is based on the BMP component references.

This research paper utilized both quantitative methods and professional expert judgment. The questionnaire approach was employed to determine the validity and reliability of the AFCI model, while the interview approach was used to support and validate the quantitative methods (Hamed Taherdoost & Lumpur, 2016). Consequently, a minimum of three experts were required, depending on the scope of the research subject, to limit the number of participants (Shrotryia & Dhanda, 2019). The study involved five experts, consisting of both educational and non-educational backgrounds.

The educational experts included instructors or course managers from the sampled BMPs, namely

PEKI4202 Basic Chemistry, as well as MSIM4311 Enterprise System Architecture and Design, and MKDK4005 Teacher Profession. The non-educational experts were professionals in graphic design and printing, represented by experts from the printing field, such as Gramedia Publisher. The experts were given the freedom to share their opinions, thoughts, comments, and suggestions in the provided space (Yusoff, 2019).

The researchers utilized this information to enhance learning activities in BMP. The questionnaire consisted of 30 items related to the construct validity, covering aspects such as template, appearance, and BMP design. These questions were divided into four indicators: visibility, aesthetics, convenience, and emphasis. This study primarily focuses on analyzing the validity and reliability of the AFCI model in improving the quality of multicolor teaching materials in ODL through the two-color separation approach. According to Post (2016), a validity coefficient ranging from 0.30 to 0.50 indicates a significant contribution to a study. The validity of the AFCI model was analyzed using a single measure correlation coefficient between raters and Cronbach's Alpha. The following formula (1) represents the correlation formula used to test the validity:

$$r_{xy} = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}} \quad (1)$$

Notes:

- $r_{xy}$  = correlation coefficient between x and y
- $n$  = number of respondents
- $\sum x$  = sum of item scores
- $\sum y$  = total scores obtained by each respondent
- $\sum x^2$  = sum of squares of items
- $\sum y^2$  = sum of squares of the total scores obtained by each respondent
- $\sum xy$  = multiplication results between the scores of questionnaire items and the total scores obtained by each respondent

## Result and Discussion

The AFCI (Analysis and Identification, Find Color, Color Composition, and Implementation) model, which utilizes a problem-based approach to achieve high-quality multicolor output in open and distance education materials, was analyzed and validated in this study. The development process of the AFCI model was divided into four stages: analysis and identification, find color, color composition, and implementation. Table 1 presents the syntax, objectives, and supporting theories of each stage.

*Analysis and Identification Color*

The categorization of teaching materials can be divided into three types: exact, semi-exact, and social (Suriadi & Fitriasia, 2023). Exact materials contain precise sciences and involve calculations, such as chemistry, physics, and mathematics. An example of an exact teaching material is PEKI4202 Basic Chemistry. Semi-

exact materials have a higher number of multimedia components and include subjects like MSIM4311 Enterprise System Architecture and Design. Social materials mainly consist of textual content with minimal multimedia components, such as MKDK4005 Teacher Profession. Table 2 below shows a sample of BMP that represents exact, semi-exact, and social groups.

**Table 1.** AFCI Model Development Syntax

Syntax	Objective	Supporting Theory
Analysis and Identification Color	Obtain identification results of color optimization in teaching materials	Instructional Principles (Alkema et al., 2023)
Find Color	Obtain two colors to be optimized into multicolor	BMP Components (Festati et al., 2015) Color Management (Shan, 2021) Color Theory (Bleicher, 2023)
Color Composition	Obtain colors with Cyan and Black color separation composition to achieve multicolor effect	Color Psychology (Elliot & Maier, 2014) Color Separation (Bleicher, 2023) Color Gradation (Bleicher, 2023)
Implementing Color Composition on Components	Obtain 2/2 color teaching materials resembling multicolor	Adobe Indesign Application (Nur Kholisho & Ismatulloh, 2023)

**Table 2.** Samples of BMP that Represent Exact, Semi-Exact, and Social Groups

Code and Name of BMP	Code and Name of BMP	Code and Name of BMP
MSIM4311 - Enterprise System Architecture and Design	Strategy management	Competitive Advantage Performance Measurement
MKDK4005 - Teaching Profession	The Role and Duties of Teachers in Learning	Educational Learning and Reflective Action for Quality Improvement Learning
PEKI4202 - Basic Chemistry	Fundamentals of Organic Chemistry	Aliphatic and Aromatic Hydrocarbons

Table 3 summarizes the identified problems and solutions in the A4 custom 2/2 BMP. Inconsistent colors and color alignment issues arise in printing. To address these problems, color management is crucial to minimize inconsistencies. Using a color chart or color

reference as a color management reference is one of the solutions to ensure appropriate colors, color consistency, and efficient color usage, which can be explored to maximize layout appearance (Sharma, 2018).

**Table 3.** Identification Problems and Solutions in the A4 Custom 2/2 BMP

Problems	Solutions
Application Microsoft Word	Application Adobe Indesign
Print color difference from RGB to CMYK	The use of CMYK colors is in accordance with printing techniques.
Change of meaning in illustration	Resembles the color sequence as the original illustration.
Limitation color only black	Multi-color of using two-color separation
Identify important words or sentences	Make highlights for important words or sentences.

*Find Color*

UT has a branding scheme with a curved shape consisting of three colors: dark blue, yellow, and gray. The curved shape conveys elegance, movement, and growth (Nabilah & Hardiyati, 2020). It reflects UT's transformation from a traditional university to an accessible, high-quality, and affordable institution (Accessibility, Quality, and Affordability). Dark blue represents wisdom, trust, maturity, and spiritual stability in decision-making. It symbolizes the integrity of Universitas Terbuka as an established and trusted

institution for 39 years. Yellow represents imagination, creativity, happiness, joy, warmth, and optimism. It shows that UT values and supports the creativity and dynamism of every individual. Gray reflects the present and future, security, and intelligence (Warna & Karja, 2021). This color represents UT's modern values, utilizing technology to connect distance learning.

Based on the corporate colors and color philosophy, the selection of dark blue falls into the cyan color category. The combination of dark blue with black becomes the key color separation, and the resulting color

combination will be further composited to create derivative colors. The colors will be tested through printing and using various printing techniques, starting from light to dark shades.



Figure 1. Full color image becomes two-color separation



Figure 2. Comparison of feedback layouts using two-color separation

*Color Composition*

The use of color composition adopts a monochrome scheme with one color involving tint, tone, and shade (Thakur, 2022). Tint is a color mixed with white, reducing its darkness and saturation. White can be mixed with any of the twelve colors on the color wheel or mixed with any of the twelve colors to create additional hues and then achieve different shades by adding a measured amount of white. Tone is produced by mixing a color with gray or by shading and tinting. Tones are created by adding white and black (gray) to paint, lightening, or darkening it, or desaturating it. Shade is a color mixed with black, increasing its darkness.

The tint, tone, and shade process are performed in the color combination stage, where cyan color is mixed with proportions of 20, 40, 60, 80, and 90. Black color is mixed with proportions ranging from multiples of 10 to 90. Figure 3 displays the color combinations of cyan and black. Before obtaining the composition formulations in Figure 3, the compositions of cyan and black colors are

mixed with equal proportions, multiples of 10 to 90. The results show insignificant color differences based on color tests through printing. The second stage involves enhancing the composition with multiples of 20 in cyan color. This composition is selected based on color test results, resulting in better derivative colors.

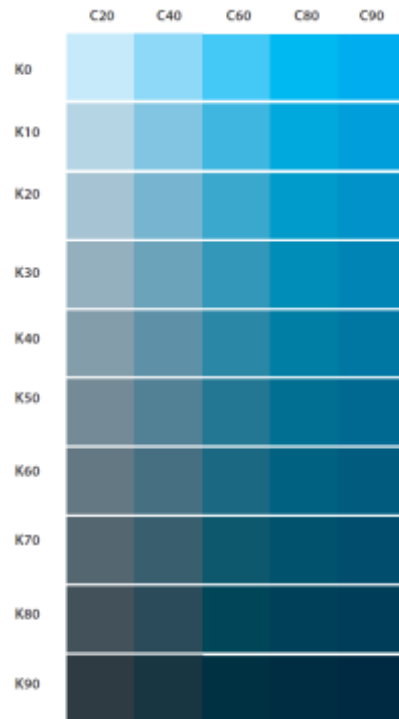
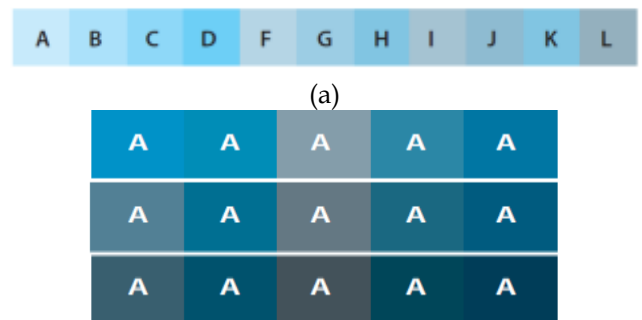


Figure 3 Color combination cyan and black

The color combinations are tested with two possibilities: black font color on colored backgrounds and white font color on colored backgrounds. Figure 4 presents examples of using backgrounds with black (a) and white font colors (b), such as black font color on cyan X and black X backgrounds, and white font color on cyan X and black X backgrounds. The color combinations are then implemented in design applications such as Adobe Illustrator and Corel Draw, using the swatches color method to add the color combinations.



(b)Figure 4. Background color on font color black (a) and white (b)

*Implementing*

The implementation of color compositions is based on the BMP component references. The application technique also follows several design principles. Design principles consist of rules, like visual grammar or guidelines, to achieve a harmonious layout composition. Good graphic design generally adheres to design principles. Kurnianto (2013) stated that the principles utilized in the model development are as follows: (a) Balance: It refers to the even distribution of visual weight. Formal balance involves symmetrical composition, where the left and right or top and bottom sections are evenly divided. Informal balance refers to an asymmetrical composition where design elements are not mirrored but still create a sense of balance. Asymmetrical balance can be achieved by considering visual weight, not just size, but also the placement of lines, colors, values, shapes, and textures. Dark-colored objects visually appear heavier than brightly colored objects; (b) Emphasis: It emphasizes the most important information to the readers. This can be achieved through

various means, such as using bright colors, enlarging photos and illustrations, using large sans-serif fonts, employing diagonal orientation, and rendering elements differently from others; (c) Contrast: Focus can be created by employing contrast techniques. It means distinguishing the most important elements from others. For example, highlighted elements are vertical when the surrounding elements are horizontal. Even bright colors become the center of attention when surrounded by black and white elements; and (d) Unity: A design is considered unified when all elements appear cohesive, and there is consistency among typography, illustrations, colors, and other design elements.

The layout process also follows similar principles to design principles. According to Guney Yuksel et al. (2023), a good layout always includes five major design principles: unity, proportion, rhythm, balance, and contrast. Table 4 displays the implementation of color compositions in BMP components by applying design and layout principles. Figures 1 and 2 are the results of implementing a two-color separation composition.

**Table 4.** Example of Implementation on BMP Components

BMP components	Design and Layout
Exterior cover	Multicolor (fullcolor) outer cover page
Inner Cover	Inner book identity cover page without images or illustrations
KDT Sheet	The Catalog in Issue (Katalog Dalam Terbitan/KDT) page contains the identity of the book with the characteristic of having an ISBN or e-ISBN number.
Table of Contents BMP	Table of contents of the entire book
MK Review	Course (Mata Kuliah/MK) Review contains discussions on each chapter or module
Module Cover	Book identity pages per module
Table of Contents of the Module	List of book pages per module
Introduction	Introduction to the material and achievements in the module
Learning Activities	Learning Activities is the material presented divided into several sub-topics of discussion
Exercise	Page contains Practice material questions
Summary	Material summary page
Formative Tests	Formative test pages in the form of multiple-choice questions
Feedback	The page contains the calculation formula for assessment and achievements from the answers to formative test questions
Bibliography	Reference pages or bibliography per module
Glossary	Pages contain descriptions of terms that are important and have meaning
Author's History	Module author description page
Cover Description	The back cover page in which there is a brief description of the contents of the book

Formula (1) can be utilized to determine the validity of each item in the questionnaire. The items are considered valid if the calculated r value (Pearson Correlation) is greater than the tabled r value (0.587). The reliability of the items is assessed using the Alpha Cronbach method, which is a standard procedure when using the SPSS program to evaluate item reliability. The Alpha Cronbach values indicate the relevance and interconnectedness of each item within the questionnaire. A value close to one signifies that the instrument is trustworthy, consistent, and efficient. According to the assessment conducted by (Taber, 2018),

an alpha value of 0.70 is considered adequately reliable in the context of this study.

Based on the six experts' analysis findings and opinions, the two-color separation BMP has an excellent average validity of 96.5 percent. Table 5 below describes the specifics of the data analyzed.

The purpose of including sections and comments from experts in the construct validity questionnaire was to gather expert opinion about the two-color modeling BMP. Experts provide their feedback in the designated space to enhance the module's quality. The researcher diligently records all improvement recommendations

from the experts, ensuring the resulting module is valid. The Alpha Cronbach's analysis yields a reliability score of 0.87, indicating high dependability of the two-color separation module. Construct validity is assessed using four variables: visibility, attractiveness, convenience, and emphasis. The findings reveal high validity coefficients:  $r_{\alpha}$  visibility = 0.98,  $r_{\alpha}$  attractiveness = 0.97,  $r_{\alpha}$  convenience = 0.91,  $r_{\alpha}$  emphasis = 1. When comparing the correlation values with the rtable value (0.587), all aspects are deemed valid.

**Table 5.** Validity and Reliability of Two-color Separation BMP

Item	Construct Validity	
	Pearson Correlation	Cronbach's Alpha ( $\alpha$ )
Visibility	0.98	0.87
Aesthetics	0.91	
Convenience	0.97	
Emphasis	1	
Average		0.965

Six specialists from different fields participated in the study. The content experts consisted of instructors or course managers from subject materials such as MSIM4311 Enterprise System Architecture and Design, MKDK4005 Teacher Profession, and PEKI4202 Basic Chemistry. Additionally, two technical experts were involved, representing the printing industry, such as Gramedia Publisher, and academic experts from design and multimedia disciplines.

The average validity score for the two-color separation BMP, based on expert evaluations, is an excellent 96.5 percent. This validity value exceeds the 70 percent threshold, indicating that the instrument has effectively measured the intended criteria and the BMP has been successfully developed to achieve its objectives. The BMP created using the R&D by Sugiyono (2014) model exhibit high validity, reasonability, and effectiveness, as evidenced by the actual two-color separation BMPs average validity rating of 96.5 percent.

The validity of the two-color separation BMP was assessed through pilot research. The Alpha Cronbach test results indicate a high reliability score of 0.87 for the BMP. Alpha scores approaching one indicate that the instrument is trustworthy, reasonable, and efficient. When the instrument's Alpha reliability rating reaches 0.70, it is considered sufficiently dependable. The results demonstrate consistent and satisfactory development of the two-color separation BMP.

**Conclusion**

The application of the AFCI model and its components has successfully yielded color quality, as demonstrated by the construct validity of the developed

AFCI model, which is deemed valid based on the criteria of a single measure interrater correlation coefficient  $r_{\alpha} >$  rtable and Cronbach's alpha reliability  $0.5 < \alpha < 1$ . Thus, the AFCI model and the exemplified BMP have proven to be valid in achieving high-quality multicolor teaching materials in open and distance education systems. Furthermore, there are potential avenues for further exploration, such as comparing the content and practical validity of this model, which could pave the way for future research and application prospects.

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**Conflicts of Interest**

There is no conflict of interest.

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