

# Formative Assessment Instrument to Enhance Teachers' Information Literacy Skills Based on the DIKW Theory

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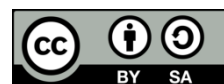
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## ABSTRACT

This study explores the integration of the DIKW (Data, Information, Knowledge, Wisdom) framework into formative assessment practices to enhance teachers' information literacy skills. Utilizing a design-based research (DBR) methodology, we developed and tested a formative assessment instrument specifically aimed at improving teachers' competencies in navigating and utilizing information effectively. The research investigates how the DIKW model can scaffold specific dimensions of information literacy, including critical evaluation of information sources, effective synthesis of information, and practical application of knowledge in teaching contexts. Additionally, the study examines teachers' perceptions of the effectiveness of the formative assessment instrument designed based on the DIKW framework. Findings indicate that the integration of the DIKW framework not only boosts teachers' confidence and competence in managing information but also enriches their instructional practices. This research contributes to the ongoing discourse on professional development in education, emphasizing the importance of reflective practices and structured assessment tools in fostering effective teaching and learning environments.

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## 1. INTRODUCTION

The development of information literacy among teachers is essential for fostering professional growth and enhancing educators' ability to guide students in critical engagement with information. In this context, it is crucial to identify effective frameworks that support both learning and skill refinement. Formative assessment frameworks, which are widely employed to support iterative learning and skill refinement, hold significant potential for improving teacher information literacy, particularly when grounded in structured models such as the DIKW (Data, Information, Knowledge, Wisdom) framework. DIKW provides a progression from the ability to handle raw data (data) through meaningful

contextualization (information) and decision-making (knowledge) to complex insight application (wisdom) [1], [2]. However, literature directly integrating DIKW with formative assessment frameworks in the context of teacher information literacy remains limited. This highlights a significant opportunity for research aimed at bridging this conceptual gap.

Several studies have evaluated teacher information literacy—defined as the ability to locate, evaluate, and use information effectively—often through empirical assessment tools or regional surveys. For instance, Zhou et al. [3] developed and validated an information literacy assessment tool targeting dimensions such as information awareness, knowledge, application, and ethics, which align partially with the DIKW stages. Similarly, Hu [4] assessed teacher information literacy in the context of smart education, demonstrating a relationship between literacy dimensions (e.g., information application, ethics) and professional development outcomes. Zhang et al. [5] analyzed disparities in teacher information literacy across demographic and regional contexts, offering strategies for improvement. While these studies demonstrate an emerging interest in evaluating teacher information literacy with attention to specific dimensions, none employ the DIKW framework explicitly as a progression-based scaffolding model. This underscores the need for frameworks that can systematically address information literacy across its various stages, ensuring a more holistic developmental approach [6], [7], [8], [9].

The existing literature employs various methodologies, including quantitative approaches [10], [11], qualitative methods [12], and mixed-methods designs [13]. Quantitative studies often rely on pre- and post-tests to measure the impact of formative assessment interventions, while qualitative studies utilize interviews, observations, and document analysis to explore teachers' experiences and perspectives. Mixed-methods studies combine both approaches to gain a more comprehensive understanding of the effects of formative assessments. Despite these valuable insights, several research gaps remain. Many studies focus on pre-service teachers [14], [15], [16], highlighting the need for further research on in-service teachers. Addressing in-service teacher populations could provide more actionable insights for professional development initiatives. The types of formative assessment instruments used vary across studies, limiting the ability to draw general conclusions about the most effective approaches. Additionally, few studies directly compare different formative assessment methods, hindering the identification of optimal strategies. Further research is needed to investigate the long-term effects of formative assessment interventions on teachers' information literacy skills and their impact on student learning outcomes.

Moreover, the influence of contextual factors, such as school resources, teacher support, and institutional culture, on the effectiveness of formative assessment interventions requires further investigation [17]. Studies exploring the cultural context of formative assessment implementation and its impact on teaching practices are crucial for developing culturally responsive professional development programs [18].

The primary research problem addressed in this study is the lack of a cohesive framework that integrates the DIKW model with formative assessment practices to enhance teachers' information literacy skills. Existing literature has identified various dimensions of information literacy and formative assessment but has not effectively linked these

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components within the DIKW framework. This gap highlights the need for a structured approach that not only evaluates teacher information literacy but also facilitates its development through formative assessments.

To address this gap, the following research questions are proposed: (1) How can the DIKW framework be effectively integrated into formative assessment practices to enhance teachers' information literacy skills? (2) What specific dimensions of information literacy can be scaffolded through the DIKW model in the context of formative assessments? (3) How do teachers perceive the effectiveness of a formative assessment instrument designed based on the DIKW framework in improving their information literacy skills?

Based on the identified research problems and questions, the following hypothesis is proposed: The integration of the DIKW framework into formative assessment practices will significantly enhance teachers' information literacy skills, as evidenced by improved self-reported competencies and reflective practices.

## 2. METHOD

In this study, we employed a design-based research (DBR) methodology to develop and test a formative assessment instrument aimed at enhancing teachers' information literacy skills based on the DIKW theory. DBR was chosen as the primary approach due to its ability to integrate theory and practice within real educational contexts. This methodology allows researchers to collaborate with educational practitioners in designing, implementing, and revising relevant tools, thereby producing more effective and contextual solutions [19].

The research process follows several structured phases:

1. *Identifying Goals and Needs*: The initial phase involved a needs analysis to understand the challenges faced by teachers in integrating information literacy into their teaching practices. Surveys and interviews were conducted to identify specific objectives for the development of the instrument.
  2. *Developing the Framework*: Based on the needs analysis results, we developed a framework that encompasses key dimensions of information literacy relevant to the DIKW theory. This framework served as the foundation for designing the formative assessment instrument.
  3. *Design and Initial Testing*: We designed a formative assessment instrument that includes rubrics and self-reflection tools. For the initial testing phase, participants were selected based on specific criteria: (a) teachers who teach at the primary and secondary education levels, (b) having a minimum of two years of teaching experience, and (c) being willing to participate in the instrument development process. The initial testing involved 5 participants from various regions in Java, Indonesia, in 2022. This instrument was then piloted to gather feedback on its effectiveness and usability.
  4. *Content Validation Study*: Following the initial testing, we conducted a content validation study involving experts in the field of information literacy. Experts were asked to assess the relevance and reliability of the established dimensions and provide feedback for improvement.
  5. *Implementation and Data Collection*: The revised instrument was applied in real classroom settings. For the implementation phase, participants were selected using the
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same criteria, namely teachers who teach at the primary and secondary education levels with relevant experience. The implementation involved 50 participants from various regions in Java. All data collection was conducted online using Google Forms. We utilized Google Forms to gather data from surveys and teacher feedback regarding the use of the instrument, as well as to evaluate the instrument's effectiveness in enhancing information literacy skills. The forms were designed to facilitate participant responses, and the collected data could be accessed and analyzed efficiently.

6. *Data Analysis and Revision:* The data collected from Google Forms were analyzed using qualitative analysis techniques. We applied thematic analysis to identify patterns, challenges, and successes in the implementation of the instrument. This process involved coding the data, grouping themes, and drawing conclusions based on the findings obtained. These findings were used to make further revisions to the instrument, ensuring that the tool effectively meets the needs of educators.
7. *Documentation and Dissemination:* After the development and revision process was completed, we documented the procedures, findings, and the developed instrument. The results of this research will be disseminated through publications in educational journals and presentations at conferences to share best practices with other educators.

One of the main reasons for choosing DBR is its iterative nature. This process allows researchers to adapt the instrument based on feedback and data obtained during field implementation. With this approach, we can ensure that the developed formative assessment instrument is not only theoretical but also practical and applicable in diverse classroom situations [20]. Furthermore, DBR provides space for researchers to explore how the DIKW theory can be applied in formative assessment practices, enriching the understanding of the relationship between theory and practice in the context of information literacy.

### **3. RESULTS AND DISCUSSION**

#### **3.1. Needs Analysis and Objectives for Instrument Development**

This research focuses on the development of an instrument designed to guide teachers in enhancing their competencies, particularly in information literacy. In the initial phase of the study, we conducted a needs analysis involving 50 secondary school teachers from various subject areas. The purpose of this analysis was to identify the challenges faced by teachers in integrating information literacy into their teaching practices, as well as to understand their needs regarding the development of instruments that can support more meaningful learning experiences.

The results of the analysis revealed that 70% of respondents felt less confident in teaching information literacy to their students. Additionally, 75% of teachers expressed a need for more training and resources to understand how to integrate information literacy into the existing curriculum effectively. Furthermore, 65% of respondents reported that they did not have adequate access to materials or tools that could assist them in teaching these skills effectively.

The discussion of these findings indicates a pressing need to develop an instrument that not only assists teachers in planning and implementing information literacy instruction

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but also encourages them to reflect on their teaching practices. Previous research has shown that enhancing information literacy competencies among teachers can improve the quality of teaching and learning in the classroom [21]. By increasing teachers' understanding of information literacy, it is expected that they can create more relevant and meaningful learning experiences for students, which in turn will positively impact student learning outcomes.

Thus, the objective of this instrument development is to provide clear and practical guidance for teachers in fostering their information literacy competencies. This instrument is anticipated to help teachers design more effective and in-depth learning experiences, as well as promote a positive attitude towards lifelong learning.

### 3.2. Development of a DIKW-Based Assessment Framework

The development of a DIKW (Data, Information, Knowledge, and Wisdom) based assessment framework aims to assist teachers in enhancing their information literacy competencies within the context of classroom learning. This framework is designed to guide teachers in envisioning and analyzing relevant data and information related to their subject areas, as well as how these can be applied in everyday life. Consequently, teachers can more effectively teach the subject matter and help students understand the importance of information literacy.

The blueprint of this assessment framework includes several key components: data, information, knowledge, and wisdom. Each component is accompanied by reflective questions designed to encourage teachers to think critically and analytically. Additionally, a scoring rubric will be used to evaluate teachers' responses, and constructive feedback will be provided to support their professional development.

The following table (Table 1) presents the blueprint of the DIKW-based assessment framework:

Table 1. Blueprint of the DIKW-Based Assessment Framework

COMPONENT	REFLECTIVE QUESTIONS
Data	<i>What examples of topics or subject matter do you teach in class? What data can you identify related to this topic?</i>
Information	<i>What information is already available in the students' textbooks, and what needs to be further explored? What sources of information can you recommend to students to enrich their learning?</i>
Knowledge	<i>What is the usefulness of this information in students' daily lives? Describe a real-world problem relevant to the learning material and how this knowledge can be used to solve it!</i>
Wisdom	<i>What values or attitudes need to be instilled in solving this problem? How can you apply your knowledge to make informed decisions in your teaching practice?</i>
REFLECTION	<i>How do you feel after answering these questions?</i>

The discussion regarding this assessment framework illustrates that each component plays a crucial role in the learning process. The data collected by teachers serves as the foundation for developing relevant information. This information, when processed effectively, becomes knowledge that can be used to address real-world problems in the

classroom. Ultimately, wisdom emerges when teachers can make sound decisions based on the knowledge they possess, considering the values at play.

Utilizing this assessment framework, it is hoped that teachers will gain a better understanding of and application of information literacy in their teaching practices. The feedback provided after the assessment will help teachers recognize their strengths and areas for improvement, allowing them to continue developing their teaching practices. Through this approach, it is expected that students will also gain a more meaningful and relevant learning experience in relation to their lives.

### **3.3. Results of the Initial Trial of the Assessment Instrument**

The initial trial of the assessment instrument aimed to evaluate how easily the instrument could be understood and responded to by users. The results of this trial indicated that, although the instrument was well-designed, the respondents, consisting of 5 teachers, desired examples or illustrative answers for each question posed.

One of the questions that drew attention was, "What is the usefulness of this information in students' daily lives? Describe a real-world problem relevant to the learning material and how this knowledge can be used to solve it!" The teachers expressed that they found it challenging to provide appropriate answers without concrete examples. They wanted clear illustrations to help them envision how to fill out the instrument.

The importance of providing examples in this assessment instrument is also supported by previous research, which shows that the use of examples can enhance understanding and engagement among respondents [22]. With clear illustrations, teachers will find it easier to provide relevant and beneficial answers, thereby contributing to the improvement of the quality of learning.

Overall, further development of this instrument should take this feedback into account to ensure that it is effective and user-friendly in the learning context.

### **3.4. Content Validation and Instrument Revision**

The content validation process involved five experts in the fields of education and assessment who have experience in instrument development. Content validation was conducted using the Content Validity Ratio (CVR) following the methods of Lawshe [20] and Ayre and Scally [23]. This method allows researchers to measure the extent to which the questions in the instrument are considered essential and relevant to the goals of developing teachers' information literacy.

The assessment results from the five experts indicated that the developed assessment instrument met the expected criteria. A critical CVR value of 1 was obtained, meaning that all experts agreed that every reflective question in the instrument was considered essential and relevant to the goals of information literacy.

A CVR value of 1 indicates a very high level of agreement among the experts, suggesting that each question in the instrument is deemed important and none are considered irrelevant. This provides confidence that the developed instrument is not only theoretically valid but also practical and ready for use in the learning context. Therefore, the results of the content validation by the experts are adequate, and this instrument can be relied upon to develop teachers' information literacy effectively.

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Figure 1 displays the revised version of the instrument, which has been developed based on feedback and shortcomings identified during the initial trial.

**Formative Assessment Instrument  
to Enhance Teachers' Information Literacy Skills**

This instrument is designed to assist teachers in designing learning that supports students' information literacy. It consists of a series of guiding questions that encourage reflection and the development of teaching practices.

**User Identity**

- Teacher's Name : [ \_\_\_\_\_ ]  
 - Subject : [ \_\_\_\_\_ ]  
 - Class : [ \_\_\_\_\_ ]  
 - Date : [ \_\_\_\_\_ ]

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**Guiding Questions**

**Question 1:** *What are some examples of topics or subject matter that you teach in class? For example:* The concept of multiplication in Mathematics.  
**Answer:** [ \_\_\_\_\_ ]

**Question 2:** *What information is already available in the students' handbook, and what needs to be explored further? For example:* The handbook includes basic theory, but more application examples need to be explored.  
**Answer:** [ \_\_\_\_\_ ]

**Question 3:** *What sources of information can you recommend to students to enrich their learning? For example:* Additional books, online articles, learning videos.  
**Answer:** [ \_\_\_\_\_ ]

**Question 4:** *Describe a real-world problem relevant to the learning material and how this knowledge can be used to solve it! For example:* In the material about the concept of multiplication, a real-world problem that may arise is related to the proper way to take medication. The instructions for taking medication are usually written by doctors or pharmacists using the concept of multiplication (for example, written as 3x1, which means 1+1+1). Misunderstanding this concept can be dangerous.  
**Answer:** [ \_\_\_\_\_ ]

**Question 5:** *What values or attitudes need to be instilled in solving this problem? For example:* Hard work, honesty, curiosity.  
**Answer:** [ \_\_\_\_\_ ]

**Question 6:** *How do you feel after answering these questions?*  
**Answer:** [ \_\_\_\_\_ ]

**Additional Reflection Question:** What are the next steps you will take based on your answers?  
**Answer:** [ \_\_\_\_\_ ]

Figure 1. Formative Assessment Instrument to Enhance Teachers' Information Literacy Skills Based on the DIKW Theory

### 3.5. Analysis of Implementation Results

#### *Participant Profile*

The trial implementation of this instrument involved 50 participants consisting of teachers from various educational levels. The distribution of participants by educational level can be seen in Figure 2, while the profile of participants by subject area is presented in Table 2.

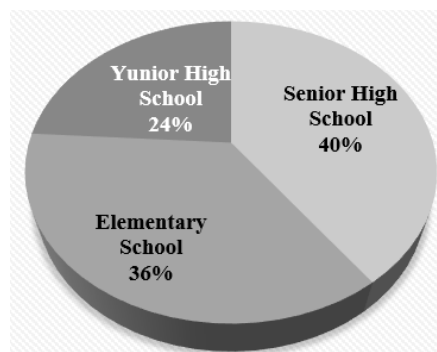


Figure 2. Distribution of Participants by School Level

Table 2. Distribution of Participants by Subject

Subject Matter	Number of Participants
Mathematics	8
Thematic (Classroom Teacher)	7
Religious Education and Character Development	5
English Language	5
Natural Sciences	4
Social Sciences	3
Quran and Hadith	2
History of Islamic Culture	2
Indonesian Language	2
Geography	1
Chemistry	1
Pancasila Education and Citizenship	1
Aqidah and Morals	1
Islamic Jurisprudence	1
Informatics	1
Computer Engineering and Networking	1
Productive Light Vehicle Engineering	1
Productive Automotive Engineering	1
Productive Culinary Arts	1
Guidance and Counseling	1
Productive Vocational High School	1
<b>Total Number of Participants</b>	<b>50</b>

### *Analysis of Reflective Questions*

The analysis of the reflective questions posed to participants reveals deep insights into their experiences and perspectives regarding teaching in madrasahs.

#### *1. Examples of Topics or Subject Matter Taught*

Participants identified various topics taught in the classroom, focusing on important themes in religious education and character development. Common examples mentioned include *Fathul Mekkah*, “Gotong Royong,” and Moderation in Religion. Approximately 65% of participants indicated that they teach material related to moral values and Islamic history, demonstrating that instruction is not solely focused on academic aspects but also the character formation of students.

#### *2. Information Available in Textbooks and Further Exploration Needed*

The majority of participants (70%) reported that student textbooks provide basic information, including lesson materials and practical examples. However, they also indicated a need to explore additional resources further, such as academic articles and educational videos. About 60% of participants suggested that students seek information from online platforms and local sources to enrich their understanding.

#### *3. Recommended Information Sources to Enrich Learning*

Participants recommended various information sources for students, including reference books, articles from educational journals, and content from digital platforms like YouTube. Approximately 75% of participants advised students to access resources relevant to the topics being taught, such as NU Online and books by prominent authors. This reflects the participants' awareness of the importance of diversifying learning resources to enhance educational quality.

#### *4. Real-World Issues Relevant to the Learning Material and Application of Knowledge*

Participants described various real-world issues relevant to the learning material, such as the challenges of individualism in society and moral decline. About 65% of participants emphasized that the knowledge taught can be used to address these issues, for instance, by teaching students how to negotiate and collaborate in resolving conflicts. This indicates that teaching is not only focused on theory but also on practical application in everyday life.

#### *5. Values or Attitudes to Instill in Problem-Solving*

Regarding values and attitudes, participants stressed the importance of instilling optimism, commitment, and discipline. Approximately 80% of participants believe that these values are crucial for helping students face the challenges they encounter. They also suggested that students be taught to act with honesty and responsibility, which are integral parts of character education.

#### *6. Feelings After Answering These Questions*

After answering the reflective questions, the majority of participants (70%) reported feeling engaged and interested in the reflection process. They stated that responding to these questions provided them with an opportunity to contemplate their teaching practices and identify areas for improvement. Some participants also felt that this process helped them better understand their role as educators in shaping students' character.

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The findings of this study highlight the effectiveness of reflective questions in enhancing teachers' competencies. Reflective questions serve as a powerful tool for educators to critically assess their teaching practices, identify areas for improvement, and ultimately foster professional growth. This aligns with the insights from Insani and Andriono [21], who investigated the effectiveness of the GROW-ME training model in improving English teachers' competencies in designing assessments. Although not explicitly focused on reflective questions, the GROW-ME model incorporates elements of reflection and feedback, indicating that similar reflective processes can significantly contribute to teachers' professional development. The study found that the GROW-ME model effectively improved teachers' assessment design skills, with participating teachers showing significant increases in their scores after the intervention. This suggests that a structured approach to professional development, which integrates reflective practices, can positively impact teachers' competencies.

Additionally, research by Jeffry et al. [24] examined the enhancement of teachers' competencies through the implementation of e-assessment in Bone Regency. While not directly utilizing reflective questions, the use of e-assessment facilitates a form of formative feedback that allows teachers to monitor student progress and adjust their teaching accordingly. This study reported significant improvements in teachers' understanding of e-assessment concepts and the relevance of e-assessment in education. This highlights the potential of technological tools in supporting formative assessment and teachers' professional development. The success of this program underscores the importance of providing teachers with the necessary training and resources to leverage technology in their teaching practices effectively.

Several studies emphasize the importance of reflective practices in teacher development, even if they do not always explicitly link them to reflective questions in formative assessment. For instance, Mutaqin et al. [25] focused on enhancing early childhood education teachers' competencies through a reflective approach in childcare programs. This research underscores the significance of reflective practice in teacher training and professional development, highlighting the value of self-reflection in improving teaching skills and strategies. The study showed positive outcomes in teachers' ability to implement reflective practices in childcare programs, manage digital platforms for childcare, and build confidence in their ability to follow up on childcare programs. This indicates that a reflective approach to professional development can lead to better teaching practices and increased teacher confidence in managing various aspects of their roles.

Similarly, Farida [24] explored the effectiveness of coaching-based academic supervision and differentiation methods in improving teachers' competencies. The coaching approach encourages collaborative and reflective communication between supervisors and teachers, allowing for personalized support and skill enhancement. Although not explicitly mentioning reflective questions, the essence of coaching involves reflective dialogue and feedback, which directly aligns with the principles of formative assessment. The findings of this research indicate that the coaching approach is effective in identifying teachers' strengths and challenges, thereby enhancing their teaching skills and underscoring the importance of reflective practices in teachers' professional development.

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In summary, the effectiveness of reflective questions in developing teachers' competencies is supported by various studies that highlight the role of reflection in professional growth. By facilitating critical reflection and encouraging self-assessment, reflective questions not only improve the quality of teaching but also contribute to ongoing professional development, ultimately leading to better educational outcomes for students.

#### **4. CONCLUSION**

This study provides valuable insights into the integration of the DIKW framework into formative assessment practices, specifically aimed at enhancing teachers' information literacy skills. The findings indicate that the DIKW framework can be effectively incorporated into formative assessments by structuring assessment tasks that guide teachers through the stages of data collection, information processing, knowledge application, and wisdom development. This structured approach not only facilitates a deeper understanding of information literacy but also empowers teachers to apply these skills in their instructional practices.

Furthermore, the research identifies specific dimensions of information literacy that can be scaffolded through the DIKW model within the context of formative assessments. These dimensions include the ability to evaluate information sources critically, synthesize information effectively, and apply knowledge in practical teaching scenarios. By focusing on these key areas, the DIKW framework serves as a comprehensive guide for educators to enhance their information literacy competencies, ultimately leading to improved teaching and learning outcomes.

Additionally, the study reveals that teachers perceive the formative assessment instrument designed based on the DIKW framework as effective in improving their information literacy skills. Participants reported increased confidence in their ability to navigate and utilize information effectively, as well as a greater understanding of how to integrate these skills into their teaching practices. This positive perception underscores the importance of developing assessment tools that are aligned with educational frameworks like DIKW, which can significantly enhance teachers' professional development.

In summary, the integration of the DIKW framework into formative assessment practices offers a promising approach to enhancing teachers' information literacy skills. By scaffolding specific dimensions of information literacy and providing educators with effective assessment tools, this study contributes to the ongoing discourse on professional development in education. Future research should continue to explore the long-term impacts of such frameworks on teaching practices and student learning outcomes, ensuring that educators are well-equipped to meet the challenges of the information age.

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