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Optimizing Academic Achievement through Comprehensive Integration of Formative Assessment into Teaching

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Abstract: Learning activities are conducted to help students achieve optimal academic achievement. This research aims to optimize student academic achievement through a learning process that integrates comprehensive formative assessments, including formative tests, self-assessment, peer assessment, and the initiator of creating summaries or concept maps that are given to students in a structured manner at the end of every lesson. The research method used was a quasi-experimental method with a 2x2 factorial design. Students enrolled in the biology education program of the basic physics course for the 1st semester of the 2019 academic year participated in this study. The participants were 66 undergraduate students divided into two classes. Thirty-four students in the experimental group were in class A, while 32 students in the control group were in class B. Data were collected using a learning outcome test instrument to measure academic achievement, which was tested at the end of the semester. Data were analyzed using a two-way ANOVA. This study concluded that a learning process that includes comprehensive formative assessment significantly affects students' academic achievement. These findings support the theory that formative assessment provides feedback, correction, and improvement in student learning.

Keywords: *Academic achievement, formative assessment, peer assessment, self-assessment, structured assignments.*

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Introduction

Student academic achievement is ideally the primary goal of learning activities. Academic achievement is the students' learning outcome after completing a set of learning activities (Amanonce & Maramag, 2020; Linn et al., 2022). The feedback students receive when participating in learning activities can encourage them to achieve optimal academic achievement (Dang et al., 2018; Kyaruzi et al., 2018; Nikolic et al., 2018; Rakoczy et al., 2019; Selvaraj & Azman, 2020; Vettori et al., 2018; Yan et al., 2020; Zhang & Hyland, 2018). Meanwhile, without feedback from formative assessments, students will struggle with learning difficulties that can be stressful. Learning activities that cause negative stress affect students' academic performance (Pascoe et al., 2020).

Formative assessment is conducted to ensure the quality of the learning process and the achievement of learning objectives. Teachers may conduct formative assessments through learning outcomes tests, structured assignments, self-assessments, and peer assessments. Formative assessment can be integrated into learning by understanding assessment as learning. Assessment practice has shifted from assessment of learning to assessment as learning (Ferm Almqvist et al., 2017; Jean de Dieu & Zhou, 2021; Suciati et al., 2020). Assessment as feedback and reflection (Mtshali et al., 2021; Torre et al., 2020) can improve students' metacognition (Braund & DeLuca, 2018), increase students' engagement in learning, and improve academic achievement (Andrade, 2019; Asadi et al., 2017; Hotaman, 2020; Rakoczy et al., 2019; Zhang & Hyland, 2018).

Assessment of learning in the form of summative assessments dominates the teaching process and excludes formative assessments (Asghar, 2012; Ganajová et al., 2021). Summative assessments only provide information about the achievement of learning outcomes at the end of learning (Al Tayib Umar & Ameen, 2021; Treve, 2021). Feedback from summative assessments does not serve students achieve learning objectives but only provides information about the score, who passed and who did not (Al Tayib Umar & Ameen, 2021; Kyaruzi et al., 2019). The summative assessment information is product-oriented, so it cannot be used to evaluate students' learning and progress during the process

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(Black & Wiliam, 2018; Treve, 2021). For this reason, some researchers advocate for a shift from practices that focus on summative assessment to formative assessments that assess the final product or student performance and provide ongoing feedback (Braund & DeLuca, 2018; Cagliero et al., 2019; Sun et al., 2019). Some studies above indicate that constructive feedback has not been optimally implemented in the teaching process. Teachers provide more feedback in the form of information about assessment scores.

Formative assessment can be an appropriate alternative to address this problem. Several research findings show that formative assessment feedback helps learners to identify students' strengths and weaknesses early (Ismail et al., 2022; Patra et al., 2022). Timely and accurate formative feedback plays a role in supporting and improving student learning and academic achievement (Al Tayib Umar & Ameen, 2021; Carrillo-De-La-Peña et al., 2009; Ferdinal & Isramirawati, 2021; Naseer Ud Din et al., 2018; Patra et al., 2022), although it is not easy in practice (Mackintosh-Franklin, 2021). Formative assessment can be used as an effective strategy to promote self-regulation and academic achievement and prepare students for the real world (Malone, 2021).

Formative assessment has not been integrated into teacher learning practices (Kippers et al., 2018). Integrating instruction with formative assessment should be maximized to promote student achievement of learning outcomes (Na et al., 2021). Assessment for and as learning is a type of assessment that focuses on metacognitive skills and helps students become lifelong learners (Torre et al., 2020). Assessment as learning should be implemented in education, reflecting a new focus on how assessment and learning are integrated (Webb et al., 2018). Assessment becomes an integral part of education and guides the teaching and learning practices that students experience (Leenknecht et al., 2021). Assessment as learning has implications for personalizing student learning (Csapó & Molnár, 2019; Jessop & Tomas, 2017). Student learning can be enhanced through assessment as learning (Kulasegaram & Rangachari, 2018).

Teachers who have implemented formative assessments do not use multiple comprehensive assessment techniques. The comprehensive assessment includes various assessment techniques, including tests of learning outcomes, self-assessment, peer assessment, and tasks to create a summary or concept of the subject matter in each instructional activity. Formative assessments comprehensively define the role of assessment as part of pedagogy (Black & Wiliam, 2018). Feedback from comprehensive formative assessments can promote student engagement in learning (Zhang & Hyland, 2018) and make adjustments that guide learning and improve achievement (Andrade, 2019). Several studies advocate using comprehensive assessments as opportunities to reinforce and enhance learning (Andersson & Palm, 2017; Andrade, 2019; Correia & Harrison, 2020; Csapó & Molnár, 2019; Kulasegaram & Rangachari, 2018).

Data on academic achievement in basic physics courses at the university level are relatively scarce. Data from the last three years show that the average student graduation rate is only 67%. However, some students can graduate after taking remedial classes and repeating the lectures the following year. This fact indicates a problem that needs to be addressed through research. Several other research findings also demonstrate low academic achievement in a basic physics course (Amir & Marisda, 2021; Jatmiko et al., 2016; Sriyanto & Sukarelawan, 2021; Sutarno et al., 2021). Several research findings above indicate that formative assessment feedback can improve student academic achievement. However, research has generally not been addressed using strategies that involve comprehensive formative assessment, including learning outcomes tests, self-assessment, peer assessment, and structured tasks that summarize instructional materials or concept maps. This study focuses on how comprehensive formative research can be integrated into learning activities to improve student academic achievement.

This research aims to optimize student academic achievement through integrated learning activities with comprehensive formative assessments. The innovation in this study is to comprehensively integrate formative assessment into the learning process and observe its effect on optimizing academic achievement. Integrating comprehensive instruction and formative assessment is an important and valid part of providing feedback and guiding student learning (Black & Wiliam, 2018; Csapó & Molnár, 2019; Kulasegaram & Rangachari, 2018; Miller & Lavin, 2007; Pailai et al., 2017). Comprehensive formative assessment allows students to gain information about the deficits and weaknesses of their learning in its entirety. The information obtained from students about learning deficiencies and weaknesses can be used to plan follow-up activities to improve their learning. Improvement of learning activities performed by students will be more targeted to optimize academic performance. Comprehensive formative assessment integrated with learning informs teachers about how students have learned and provide indicators of how teachers should plan their next lesson (Wuest, D. A., & Fisette, 2012).

Literature Review

Academic Achievement

Academic achievement is a learning outcome that students can achieve after participating in a series of learning activities. Academic achievement is optimal when students can achieve academic achievement according to their learning capacity. Learning capacity is how individuals recognize, assimilate, and use knowledge (de Aguiar et al., 2020). Various disturbances and events during the reception of feedback information affect the optimization of students' learning skills (Marinelli et al., 2017; Sancho-Zamora et al., 2022). Therefore, innovation in the learning process that provides more feedback is needed to improve students' academic achievements (Gunawan et al., 2018; Sujito et al., 2021).

Some results have shown that students' academic achievement can be optimized through learning activities and formative assessments conducted at each session of learning activities. Formative assessment aims to correct and improve (Andrade, 2019; Dalby & Swan, 2019; Dini et al., 2020; Pailai et al., 2017). Formative assessment can improve academic achievement (Dalby & Swan, 2019; McDonald & Boud, 2003; Yakob et al., 2021). Students receive feedback for their learning improvements (Hotaman, 2020; Kippers et al., 2018). Feedback received during the learning process is essential for self-regulated learning (Correia & Harrison, 2020; Kippers et al., 2018; Pailai et al., 2017; Rakoczy et al., 2019; Romero et al., 2017).

Formative Assessment

Formative assessment is oriented toward "assessment as or for learning," which is planned through various assessment activities to obtain information about student learning or evidence used to adjust teachers or student learning strategies (Chen et al., 2021). Formative assessment is aligned with learning goals (Csapó & Molnár, 2019; Dini et al., 2020; Sun et al., 2019). Students' focus on their goals, interests, and orientation of learning objectives is enhanced through formative assessment (Hotaman, 2020). Formative assessment helps students gain hands-on and authentic experiences to provide feedback for improvement (Braund & DeLuca, 2018). Improvement in student achievement is possible when formative assessments are done well and consistently (Dalby & Swan, 2019; Kippers et al., 2018).

Formative assessment aims to help students develop their capacities by calibrating and refining their assessment through feedback from others (Panadero et al., 2019). In addition, formative assessments provide feedback to improve and accelerate learning (Nikolic et al., 2018). Formative assessments are a variety of feedback actions that teachers and students use to guide teaching and learning (Dayal, 2021). Feedback is information from the formative assessment fed back into the instructional system. Research shows that feedback is key to student learning (Lipnevich & Panadero, 2021). In addition to providing feedback to promote and improve student learning, the formative assessment also provides feedback information for teachers that is useful in adapting their teaching methods (Al Tayib Umar & Ameen, 2021).

Some studies focus on peer and self-assessment. These studies show that peer assessment and self-assessment can influence students' academic achievement (Hamodi et al., 2017; Yan & Brown, 2017; Zulliger et al., 2022) and support students' competencies in inquiry-based science (Grob et al., 2017). Hamodi et al. (2017) found that formative assessment and feedback were not widely carried out during the learning process. Yan and Brown research (2017) found that three actions are commonly carried out in the self-assessment process: determining performance criteria, seeking self-directed feedback, and self-reflection. The study by Zulliger et al. (2022) shows that self-assessment and peer assessment benefit lower-performing students. Meanwhile, Grob et al. (2017) found that structured formative assessment in inquiry-based science education can improve student competence. However, peer and self-assessments should be used with caution. This is because peer and self-assessments can bias formative assessments due to student intrapersonal and interpersonal factors (Kyaruzi et al., 2018). In self-assessment, students assess their achievements by examining the results of their work, whereas, in peer assessment, students assess the abilities of their peers and the consequences of group work (Grob et al., 2017; Hamodi et al., 2017). Students who assess themselves effectively can identify their academic strengths and weaknesses, organize themselves effectively, and develop adaptive learning strategies to achieve better performance (Yan & Brown, 2017).

Feedback from learning outcomes tests helps guide learning and improve student learning outcomes (Tai et al., 2018). However, formative assessment through learning outcomes tests and reviewing students' work against criteria and standards is a common method used by teachers. In addition, feedback that gives test results as learning outcomes may have a negative impact on student performance (Bulut et al., 2019). On the other hand, teacher feedback based on formative assessments through learning outcomes tests and structured assignments is very much liked by students (Kyaruzi et al., 2019). Formative assessment through structured tasks can guide student learning (Richards-Babb et al., 2018). Formative assessment through assignments to create summaries or concept maps of teaching materials improves student learning outcomes (Sumanik et al., 2020).

These studies have shown that feedback from a variety of formative assessment techniques has an impact on student performance. The study results indicate that all types of formative assessments provide information that serves as feedback for students and teachers. Nevertheless, these studies examined the effect of formative assessment techniques on partial performance. No studies have comprehensively examined the impact of formative assessments on student performance. The comprehensive assessment involves various formative assessment techniques simultaneously in a learning activity, namely learning outcome tests or practice questions, peer assessment, self-assessment, and creating a summary or concept map of the instructional material. Comprehensive formative assessment is suspected of providing complete information and feedback for students and teachers so that it should optimally improve students' academic performance. For this reason, this study was conducted.

Methodology

Research Design

In this study, a quasi-experimental method was used because it is impossible to draw a random sample but a purposive sample, namely that of the existing class. Quasi-experimental research is the most widely used research approach to evaluate social work programs and policies (Thyer, 2012). The research design used was a 2x2 factorial design. Dependent variables are academic achievements in the form of final test scores of basic physics courses. The independent variables in this study are the learning process and achievement index. In this study, the learning process was used as the treatment variable, and the performance index was used as the moderator variable. The learning processes were divided into two groups: (a) Experimental group: a learning process that integrates formative assessments extensively, including learning outcome tests in the form of practice questions, self-assessment, peer assessment, and structured tasks that produce a summary of the teaching material or concept maps at the end of each learning session. Students receive information-based feedback on all formative assessment techniques throughout the learning process. At the end of the learning process, students were asked to work in groups to create a summary of what they had learned in the form of a concept map and present it. In addition, the teacher provided feedback based on his assessment of the concept map presented by the students. (b) Control group: the learning process with formative assessment was only in the form of a test of learning outcomes in the form of practice questions without self-and peer assessment and without the task of creating a summary of the lesson materials or concept maps. During the learning process, students received feedback from the instructor on their performance in completing the practice questions.

The moderator variable is the achievement index of 1st-semester students, which is divided into two categories, high and low. The learning outcome test is influenced by the learning process and the achievement index. The achievement index (AI) is the average grade of all courses students have taken. The course grade is the number, or conversion result score, of the course grade achieved by the student. In this study, AI was grouped into high and low categories. The category is high if AI ≥ is 2.75 and low if AI is <2.75. The conversion of grades obtained by students into numbers, or scores, is as follows: A= 4, B = 3, C = 2, D = 1, F = 0. The following formula calculates IP.

$$AI = \frac{\sum N \ x \ SCU}{\sum SCU}$$

Note:

IP = Achievement Index

N = Course grade after conversion to numbers

SCU = semester credit units for each course

Participants

The participants in this study were all undergraduate biology majors taking basic physics courses. The number of participants was 66 students divided into two classes. The first class with 34 students was used as the experimental group, and the second class with 32 students was used as the control group. The demographic data of the students in this study are shown in Table 1.

Table 1. Demographic of Research Participants

Demographic Aspects		**N = 66**	**%**
Sex	Male	9	13.6
	Female	57	86.4
Age	18	16	24.2
	19	42	63.7
	20	8	12.1
Educational Background	Public High School	61	92.4
	Vocational High School	5	7.6
Achievement Index	≤ 2.00	3	4.5
	2.01 – 3.00	45	68.2
	3.01 – 4.00	18	27.3

Instrument and Data Collection

The instrument used to measure academic achievement is a learning outcome test consisting of 40 multiple-choice items with five response options. Before being used for data collection, the research instruments were first tested for validity and reliability. The experiment was conducted with 75 students who had passed the basic physics course. The validity and reliability of the test were checked by Rasch model analysis techniques using the Winstep application. The statistical values of the sequence items of the research instruments are presented in Table 2.

Table 2. Measure Order Instrument Items

Entry Number	Total Score	Total Count	Measure	Model S.E.	Infit		Outfit		PT-Measure		Exact Match		Item
					MNSQ	ZSTD	MNSQ	ZSTD	Corr.	Exp.	OBS %	Exp %	
37	11	75	2.64	.34	1.22	1.0	1.61	1.5	-.01	.28	84.0	85.4	N37
21	15	75	2.23	.31	1.27	1.5	1.46	1.5	.02	.31	77.3	80.4	N21
40	24	75	1.50	.27	1.56	4.3	2.29	5.2	-.28	.36	58.7	71.3	N40
15	25	75	1.43	.26	.81	-1.8	.71	-1.8	.57	.36	7.33	70.3	N15
22	25	75	1.43	.26	.82	-1.7	.72	-1.7	.56	.36	70.7	70.3	N22
38	26	75	1.36	.26	.98	-.1	.96	-.2	.38	.37	70.7	69.6	N38
6	28	75	1.23	.26	1.00	.0	.99	.0	.38	.37	65.3	68.5	N6
9	31	75	1.03	.25	.90	-1.1	.88	-.9	.48	.38	69.3	67.3	N9
23	32	75	.97	.25	.98	-.2	.98	-.1	.40	.38	70.7	67.0	N23
12	35	75	.78	.25	.99	-.1	1.08	.6	.38	.39	69.3	66.4	N12
8	36	75	.72	.25	.92	-.9	1.06	5	.44	.39	73.3	66.4	N8
19	37	75	.65	.25	1.03	.4	1.09	.7	.35	.39	62.7	66.4	N19
5	38	74	.55	.25	1.00	.1	.97	-.2	.39	.39	63.5	66.6	N5
10	39	75	.53	.25	1.19	2.1	1.35	2.6	.18	.39	58.7	66.7	N10
16	39	75	.53	.25	1.06	.7	1.04	.4	.33	.39	61.3	66.7	N16
24	41	75	.40	.25	1.09	1.0	1.17	1.3	.29	.39	65.3	67.2	N24
14	42	75	.34	.25	.98	-.2	.98	-.1	.41	.39	66.7	67.5	N14
34	42	75	.34	.25	1.07	.8	1.11	.9	.31	.39	69.3	6.75	N34
39	43	75	.27	.25	.99	-.1	.99	-.1	.40	.39	69.3	67.9	N39
33	45	75	.14	.26	.90	-1.1	.99	.0	.46	.39	81.3	68.7	N33
11	46	75	.08	.26	.91	-.9	.89	-.8	.48	.39	74.7	69.1	N11
7	48	75	-.06	.26	.81	-1.9	.76	-1.7	.58	.38	80.0	69.9	N7
28	48	75	-.06	.26	.97	-.2	.89	-.7	.43	.38	66.7	69.9	N28
4	49	75	-.13	.26	1.18	1.6	1.27	1.6	.19	.38	68.0	70.4	N4
13	49	75	-.13	.26	.82	-1.8	.81	-.1.2	.56	.38	78.7	70.4	N13
27	51	75	-.27	.27	1.08	.7	1.07	.4	.30	.38	68.0	71.7	N27
25	51	74	-.34	.27	1.02	.2	.96	-.2	.36	.37	73.0	72.1	N25
2	54	75	-.49	.28	.95	-.3	.92	-.4	.42	.37	78.7	7.44	N2
30	55	75	-.57	.28	.88	-.8	.78	-1.1	.49	.37	77.3	75.5	N30
18	56	75	-.65	.29	.81	-1.4	.67	-1.6	.57	.36	78.7	76.6	N18
3	57	75	-.73	.29	.94	-.4	.85	-.6	.43	.36	80.0	77.7	N3
36	57	75	-.73	.29	.91	-.6	.85	-.6	.45	.36	80.0	77.7	N36
35	59	75	-.91	.30	.98	-.1	1.29	1.1	.31	.35	82.7	80.0	N35
32	60	75	-1.00	.31	.94	-.3	.72	-1.0	.45	.34	78.7	81.2	N32
20	63	75	-1.31	.34	.90	-.4	.85	-.4	.41	.32	86.7	84.8	N20
29	63	75	-1.31	.34	1.01	.1	1.11	.4	.28	.32	86.7	84.8	N29
26	66	75	-.1.69	.38	1.04	.2	1.18	.6	.23	.30	88.0	88.3	N26
17	68	75	-2.00	.42	1.00	.1	1.12	.4	.23	.27	92.0	90.8	N17
31	71	75	-2.65	.53	.89	-.1	.46	-.7	.37	.22	94.7	94.7	N31
1	74	75	-4.15	1.02	82	.1	.11	-.8	.35	.12	98.7	98.7	N1
Mean	45.0	74.9	.00	.30	.99	.0	1.00	.1			74.8	74.2	
S.D.	15.0	.2	1.28	.13	.14	1.1	.33	1.3			9.5	8.4	

Statistical values for examining fit and misfit instrument items can be obtained from Table 3. To determine whether an item falls into the fit or misfit category, compare the Infit MNSQ to the sum of mean and SD. If the Infit MNSQ is greater than the sum of mean and SD, then the item indicates a Misfit (Fleary et al., 2022; Han, 2022; Indihadi et al., 2022). For example, Table 2 shows that the values of Mean and SD are 0.99 and 0.14, respectively, so the sum of both values is 0.99 + 0.14 = 1.13. Thus, from these criteria, five items of the instrument with an infit value of the MNSQ greater than 1.13 have a misfit, namely N4 (+1.18), N10 (+1.19), N21 (+1.27), N37 (+1.22), and N40 (+1.56). Thus, 35 items fall into the fit or valid category, and five items fall into the misfit or invalid items. In addition, the misfit items are corrected and then retested so that all items in the instrument meet the fit or validity criteria.

The data accuracy value with the infit and outfit model can be seen from the values of infit and outfit given in the person table in terms of infit MNSQ (Infit Mean Square) and outfit MNSQ (Outfit Mean Square). The table shows that the values of the two are in the range of 0.99 and 1.00. The ideal value is 1.00, i.e., the closer to 1.00, the better. The values of Infit ZSTD (Infit Z standard) and Outfit ZSTD (Outfit Z standard) in the person table were 0.00 and 0.10, respectively, and the ideal value is 0.00, i.e., the closer to 0.00, the better. The values of Infit MNSQ and Outfit are 0.9 and 1.00, respectively, while the values of Infit ZSTD and Outfit ZSTD are 0.00 and 0.10, respectively. Based on the Infit value and Outfit for person and item, it can be concluded that the quality of the instruments can be classified as very good.

Table 3. Summary of 75 Measured Person

	Total Score	**Count**	**Measure**	**Model Error**	**Infit**		**Outfit**	
					MNSQ	**ZSTD**	**MNSQ**	**ZSTD**
Mean	24.0	40.0	.61	.39	.99	.0	1.00	.1
S.D.	6.4	.2	.93	.04	.18	1.0	.36	.8
Max.	36.0	40.0	2.70	.56	1.85	2.0	2.96	2.4
Min.	6.0	39.0	-2.18	.36	.65	-2.8	.45	-1.8
Real RMSE .40		True SD .84		Separation 2.08		Person Reliability .81		
Model RMSE .39		True SD .84		Separation 2.16		Person Reliability .82		

Summary of 75 Measured Person
SE of Pearson Mean = .11
Pearson Raw Score to Measure Correlation = 1.00
Cronbach Alpha (KR-20) Pearson Raw Score "Test" Reliability = .83

Table 4. Summary of 40 Measured Items

	Total Score	**Count**	**Measure**	**Model Error**	**Infit**		**Outfit**	
					MNSQ	**ZSTD**	**MNSQ**	**ZSTD**
Mean	45.0	74.9	.00	.30	.99	.0	1.00	.1
S.D.	15.0	.2	1.28	.13	.14	1.1	.33	1.3
Max.	74.0	75.0	2.64	1.02	1.56	4.3	2.29	5.2
Min.	11.0	74.0	-4.15	.25	.81	-1.9	.11	-1.8
Real RMSE .33		True SD 1.23		Separation 3.68		Person Reliability .93		
Model RMSE .33		True SD 1.23		Separation 3.75		Person Reliability .93		

Summary of 40 Measured Items
SE of Item Mean = .20
UMEAN = .0000 USCALE = 1.0000
Item Raw Score-to-Measure Correlation = -.96
2998 Data Points. Log-likelihood Chi-Square: 3075.24 with 2884 d.f. p = .0067
Global Root-Mean-Square Residual (Excluding Extreme Score): .4131

A summary of the 75 Measured Pearson and 40 measured items is provided in Table 3 and Table 4, respectively. Both tables show that the logarithm odds unit has an average respondent value of 0.61 from the 0 and 1 scale range. The person reliability value is 0.81, which is in the "good" category, while the item reliability is 0.93, which is in the "excellent" category. The reliability value of Alpha Cronbach (KR -20), which indicates the interaction between the respondents and the instrument's items, is 0.83 and can be classified as very good. Thus, based on the magnitude of the reliability of the respondents and the reliability of the items, it can be concluded that the consistency of the respondents' answers is sufficient and the quality of the items of the instrument is excellent, while the interaction between the respondents and the items of the instrument is good overall.

Data collection was conducted after students had completed all of the course units for a total of 14 sessions. The data collection was conducted in conjunction with the end-of-semester examinations according to the schedule and academic calendar of Pakuan University. The data collection was conducted by testing the experimental and control groups with the same instrument, namely the test of learning outcomes of basic physics courses, which was tested for validity and reliability. The test was administered for 100 minutes. The data of this study are the exam scores obtained by the students.

Research Procedure

This research was conducted during the 1st semester of the 2019 school year. This research was conducted in the biology education program, Faculty of Teacher Training and Education, Pakuan University, Bogor, West Java, Indonesia. At the beginning of the semester, students in the experimental and control groups were explained the learning activities in which they would participate for a semester. The learning activities are referred to as research procedures and are shown in Table 5.

Table 5. Research Procedure

Activity	Experiment Group	Control Group
Learning process	Teachers guide and facilitate student learning activities for as many as 14 sessions per semester. The teaching material follows the syllabus of the basic physics course. Learning methods vary, including practicum activities in the laboratory.	The teacher guides and facilitates student learning with the same activities as the experimental group.
	Students participate in a whole series of learning activities for one semester.	Students participate in a whole series of learning activities for one semester, as is done in an experimental class.
Test learning outcomes or practice questions and feedback during the learning process.	During the learning activity, the teacher gives practice questions according to the teaching meter and immediately provides feedback.	The teacher also carries out the same process in the control group.
	Students practice questions and receive teacher feedback according to weaknesses identified through practice questions.	Students do the same practice questions in the experimental class and receive feedback in the experimental group.
Peer assessment and feedback	Teachers divide students into six groups with group members between 5-6 students. They should discuss the completion of the tasks prepared by the teacher. All students are asked to participate in the discussion actively. The teacher asks each group to present the results of their discussion so that the other group can respond or give feedback. The teacher reminds students that responses must be appreciative and constructive.	The teacher does not conduct group discussion activities in the control group during the learning process.
	Students conduct group discussions and present the results of their discussions in turn. Then the other groups respond or give feedback to the group presenting the results of their discussion, and so on until all six groups have presented their results and received responses from other groups.	In the control group, there are no group presentation activities or feedback from other groups.
Self-assessment and feedback	Toward the end of the learning activity, the teacher asks students to complete a self-assessment by filling out the prepared self-assessment instrument or verbally asking for the teaching material (depending on the time available). The teacher then provides feedback based on the results of the self-assessment.	In the control group, teachers are not having students do self-assessments.
	Students fill in instruments or answer self-assessment questions and receive feedback.	Students do not self-assess and receive feedback.
Create a summary or concept map and feedback	At the end of the activity, the teacher asked the six students to make a summary of what they had just learned in the form of a concept map. The concept map can be related to the previous material. Each group, represented by one of its members, was asked to present their concept map briefly. Then the teacher gives appreciative and constructive feedback.	Teachers do not ask students to create summaries or concept maps.
	In groups, students summarize teaching materials as a concept map. Students receive feedback from teachers on the concept map they have created.	Students do not create summaries or concept maps and receive feedback.
Final Exams	The teacher conducts and supervises the final exams according to the schedule set by the university. Then the teacher reviews the results and uses the academic achievement data in that study.	The teacher conducts and supervises the final exams according to the schedule set by the University. Then the teacher reviews the results and uses the data on academic achievement data in this study.
	Students take final exams for basic physics courses as scheduled.	Students take final exams for basic physics courses as scheduled.

Data Analysis: The descriptive statistical analysis calculated the mean and standard deviations. Rasch model analysis was used to assess the validity and reliability of the instrument. The two-way test ANOVA was used to determine if there was a significant difference in average academic achievement between experimental and control students, with the achievement index's moderator variables. Before using the two-way test ANOVA, the normality of the data distribution and the homogeneity test of the variance of the four data groups were first conducted. The Kolmogorov-Smirnov technique was used for the normality test, and the Levene's technique was used for the homogeneity test.

Results

The descriptive statistics on the score data for the final exam in physics are shown in Table 2. The descriptive statistics in Table 6 show that the average academic achievement score for the experimental group was 40.26, that of the control group was 37.63, and the average total score was 38.98. When grouped based on achievement index variables, the results are as follows: (a) in the group of students with a high achievement index in the experimental group, the average academic achievement score is 40.87; (b) in the group of students with high achievement index in the control group, the average academic achievement score is 41.20; (c) in the group of students with low achievement index in the experimental group, the average academic achievement was 39.79; and (d) in the group of students with low achievement index in the control group, the average academic achievement score is 31.67.

Table 6. Descriptive Statistics of Academic Achievement

Learning Process	Achievement Index	Mean	SD	N
Experimental Group	High	40.87	4.190	15
	Low	39.79	3.537	19
	Total	40.26	3.816	34
Control Group	High	41.20	3.622	20
	Low	31.67	5.433	12
	Total	37.63	6.364	32
Total	High	41.06	3.819	35
	Low	36.65	5.874	31
	Total	38.98	5.336	66

Data analysis requirements using the two-way method ANOVA included normality and variance homogeneity tests for each data distribution group. First, the normality of the distribution of the data groups was tested using the Kolmogorov-Smirnov technique. The normality test results show that the distribution of the four academic achievement scores is normally distributed. The homogeneity test of the variance of the learning achievement data used the Levene's technique. The homogeneity test showed that the variance of the four distributions of academic achievement data was homogeneous.

The results of the inferential statistical analysis of the academic achievement data using the two-way procedure ANOVA are presented in Table 7. The correction tests for the effects of the treatment variables, namely the learning process, achievement index, and the interaction of the learning process with the achievement index on academic achievement, yielded the parameter $F = 15.948$ with a significant value of $p = .000 < .05$. That is, the obtained model is valid.

The test of the influence of the learning process on learning achievement in fundamental physics subjects shows that the F value for the variable learning process is 14.253 with a significance value of $p < .001$. These results indicate that there is a significant difference between the average student achievement scores in the experimental group and the control group. In this case, student achievement in the experimental group, with an average of 40.26, was higher than the average student achievement in the control group, with 37.63. The results of this test indicate that the learning process in which formative assessment is integrated includes formative tests, self-assessments, peer assessments, and summary or concept map tasks and significantly affects student academic achievement.

Table 7. Summary of Two-Way ANOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	806.227[a]	3	268742	15948	.000
Intercept	93294957	1	93294957	5536486	.000
Learning Process	240175	1	240175	14253	.000
Achievement Index	445642	1	445642	26446	.000
Learning Process * Achievement Index	283046	1	283046	16797	.000
Error	1044758	62	16851		
Total	102159000	66			
Corrected Total	1850985	65			

Dependent Variable: Academic Achievement
a. R Squared = .436 (Adjusted R Squared = .408)

The test results of the effect of the achievement index variable on learning achievement in basic physics yielded the F value for the achievement index variable of 26.446 with a significance value of $p < .001$. The results of this test indicate a significant difference between the average scores of students with a high achievement index and those with a low achievement index. The average academic achievement in basic physics subjects of students with a high achievement index of 41.06 is higher than the average academic achievement of students with a low achievement index of 36.65. The achievement index, used as a moderator variable in this study, significantly affects students' academic achievement in basic physics subjects. The F-value for the interaction between the learning process variables that comprehensively integrate formative assessments and the achievement index is 16.797 at a significance value of $p < .001$, indicating that there is an interaction between the learning process that incorporates formative assessments and the achievement index with students' academic achievement in basic physics subjects.

Table 8. Pairwise Comparisons

		Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
(I) Learning Process	**(J) Learning Process**					
Experiment	Control	3.895*	1.032	.000	1.833	5.957
(I) Achievement Index	**(J) Achievement Index**					
High	Low	5.305*	1.032	.000	3.243	7.367

Dependent Variable: Academic Achievement
Based on estimated marginal means
a. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Other tests using the Tukey technique are shown in Table 8. The table shows that the average academic achievement is significantly different for all groups. In this study, it was found that the number of students with a high achievement index, that is, the average academic achievement of students in the experimental group, was 40.87 lower than that in the control group, which was 41.20 (see Table 6). The average academic achievement of students with a high achievement index tends to be low when they follow a comprehensive learning process incorporating formative assessments. In contrast, students who participate in a learning process that involves formative assessments only in the form of tests tend to have high average academic achievements.

In the group of students with a low achievement index, the experimental group's average academic achievement in basic physics subjects was 39.79, which was higher than that in the control group, which was 31.67 (see Table 6). This result indicates that the average academic achievement of students with a low achievement index tends to be high when they engage in a learning process that integrates formative assessments extensively. However, the average academic achievement tends to be lower for students who only participate in a learning process that includes formative assessments in the form of tests.

Discussion

This study found that feedback from comprehensive formative assessment results at the end of each learning session could improve students' academic performance in basic physics subjects. This study consistently shows that academic achievement in physics subjects can be enhanced through feedback (Molin et al., 2021). Moreover, formative assessment affects students' academic achievement and attitudes toward teaching (Ozan & Kıncal, 2018; Zulliger et al., 2022). Therefore, teachers need to understand the function of formative assessment as "assessment as and for learning" because it will influence their actions in the learning process. These findings are consistent with the results of other studies showing that teachers' efforts to provide feedback that focuses on reflective pedagogy are influenced by their understanding of formative assessment as learning (Tigelaar & Sins, 2021).

Feedback from a comprehensive formative assessment is constructive for students and helps them self-direct their learning. Students are well informed to know which parts of the course material should be re-learned more intensively to improve their academic performance. The feedback students receive a scaffold to revisit their learning and optimize their academic achievement (Kyaruzi et al., 2018, 2019; Webb et al., 2018), engagement, learning outcomes, and student perceptions (Chen et al., 2021; McCallum & Milner, 2021). In addition, students can use their metacognition through formative assessments by learning what content they have already understood or not understood (Na et al., 2021). This study shows that it must be a concern for teachers to provide as much feedback as possible to students through comprehensive formative assessments as part of learning methods. These findings are consistent with the results of other relevant studies (Linn et al., 2022; Rakoczy et al., 2019; Yusefzadeh et al., 2019). Integrating comprehensive formative assessments into the learning process can increase student engagement and enthusiasm for learning. These findings are consistent with previous research in various fields showing that feedback effectively triggers corrective effort, increased student motivation, and learning intensity (Double et al., 2020; Kulasegaram & Rangachari, 2018; Nikolic et al., 2018; Rakoczy et al., 2019).

Learning activities that integrate comprehensive formative assessments allow for more comprehensive feedback for students. Formative assessment through learning outcomes assessments impacts student engagement, student perceptions of formative assessment, and learning outcomes (Chen et al., 2021). Self-assessment and peer assessment help improve students' reflective thinking, metacognition, and self-regulation skills (Braund & DeLuca, 2018). Assignments include summarizing course material or creating a concept map to improve students' attitudes and understanding of course material (Richards-Babb et al., 2018; Sumanik et al., 2020). Teacher feedback based on comprehensive formative assessment can guide student thinking and action in the future (Correia & Harrison, 2020). Thus, comprehensive formative assessment feedback can guide efforts to improve learning and optimally improve student learning outcomes.

The study also showed that a learning process that integrates comprehensive feedback affects academic achievement differences between students with a high and low achievement index. Comprehensive feedback in groups of students with a low achievement index affects their higher academic achievement than those with a high achievement index. These findings suggest that caution should be used in providing feedback on formative assessment results to groups of students with a high achievement index. Teachers should be careful to specify the scope of feedback material, how the feedback is delivered, and the timing of the feedback. Feedback should be provided as soon as the formative assessment has been made (Csapó & Molnár, 2019; Gamage et al., 2019; Kulasegaram & Rangachari, 2018; Tempelaar et al., 2018; Zhang & Hyland, 2018). How feedback is recommended is personal (Csapó & Molnár, 2019; Sagarika et al., 2021). If feedback is given inappropriately, the time and scope of metering can be counterproductive.

The findings and discussion presented above indicate that the learning process that integrates comprehensive formative assessment with comprehensive learning outcomes testing, self-assessment, peer assessment, and structured tasks given by teachers can provide complete feedback that can help students direct their learning and improve their understanding of course material through purposeful thinking and action, which ultimately enhances their academic achievement. In reviewing previous studies, we did not find any studies that contradicted our research findings. Thus, in practice, the results of this study contribute to efforts to improve instructional practices by integrating comprehensive assessments into the learning process. Theoretically, the findings of this study contribute to expanding the theory about the function of formative assessment as learning and assessment for learning.

Conclusion

The learning process that integrates comprehensive formative assessment with multiple assessment techniques simultaneously has a more optimal impact on student academic achievement than the learning process that uses only one formative assessment technique, namely the learning outcomes test. Moreover, comprehensive formative assessment in learning activities can provide students with more prosperous and constructive feedback. The feedback offers optimal input to guide students' reflective thinking and actions to improve their understanding and academic performance. This research practically contributes to improving the quality of teaching practice, especially in fundamental physics subjects and subjects with similar characteristics. In this context, a learning process that includes comprehensive formative assessment and prompt and personalized feedback is highly recommended. In addition, the results of this study contribute to the development of the literature and the strengthening of the theory of formative assessment as learning and formative assessment for learning.

Finally, as researchers, these results reinforce our belief in the massive use of comprehensive formative assessments in learning activities. However, these results need to be further tested through similar research on courses and participants with different characteristics. We hope these results will encourage researchers with similar interests to conduct further research.

Recommendations

Teaching and learning activities that comprehensively integrate formative assessments can significantly improve student academic performance. Therefore, the study recommends that teachers implement a teaching and learning activities model incorporating formative assessments. In addition, faculty leaders or educational institutions must establish policies that support teachers in implementing comprehensive integration of formative assessments into their teaching and learning activities. Comprehensive formative assessment is a formative assessment that includes the use of testing techniques, self-assessment, peer assessment, and assignment to make a summary or concept map of the instructional material learned.

Researchers with similar interests are advised to review these results and conduct similar studies but use methods, courses, and participants with different characteristics. For further research, it is necessary to perform a comparative analysis to compare which formative assessment techniques are most effective in improving the quality of student learning processes and outcomes. In addition, it is necessary to conduct research that uncovers and analyzes the variables that act as mediators to increase the effectiveness of formative assessment feedback on student learning behaviors.

Limitations

This research was conducted to apply the principle of formative assessment as learning based on the teacher's dimensions. The integration of comprehensive formative assessments in teaching and learning activities and their effect on academic achievement became an essential focus of this study. The limitation of this study is that the research is conducted only from the teacher dimension without structurally including the support of faculty leaders and administrators. Their non-involvement in supporting this study became the weak point of the research we conducted. Integrating comprehensive formative assessment into teaching and learning activities, the focus of our research will be stronger if it involves all dimensions, namely teachers, leaders, and faculty administrators. In our case, integrating comprehensive formative assessments into teaching and learning activities is not the policy of faculty leaders. This type of research is a natural condition over which we have no control. However, we are working seriously to ensure that this research goes well according to our plan.

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Authorship Contribution Statement

Hidayat: Concept and design, data acquisition, data analysis/interpretation, drafting manuscript, critical revision of manuscript, statistical analysis, editing/reviewing. Irdiyansyah: Drafting manuscript, technical or material support, supervision.

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