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Optimization Student Learning Outcomes Through Hyflex Learning Based on Student Engagement

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Abstract

Student engagement is an important factor in determining learning outcomes, but in online learning in particular, many obstacles are still faced. On the other hand, studies on the implementation of effective online learning are still limited. This study presents an empirical synthesis of the relationship between student engagement and learning outcomes in HyFlex through a random effects meta-analysis supported by a student survey. The meta-analysis results estimated via OpenMEE show a positive and significant overall effect. There was very high heterogeneity between studies, but subgroup analysis by education level showed no significant differences. Diagnostic publication bias indicated asymmetry, but the large Rosenthal fail-safe N value, supported the stability of the findings. Survey data showed an average of 81% positive responses in synchronous and asynchronous modes, including active participation, material comprehension, frequent access to asynchronous material, and task completion support. Respondents also rated learning interaction, learning atmosphere, self-motivation, and self-discipline as the main factors driving engagement. Overall, these findings confirm that student engagement are key determinants of learning outcomes in HyFlex, and emphasize the need for HyFlex designs that emphasize meaningful interaction, accessible media, and self-regulation support. Further research is needed to test contextual moderators and clarify the conditions that most support the effectiveness of HyFlex Learning.

Keywords: HyFlex learning; learning outcomes; meta-analysis; quantitative survey; student engagement

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1. Introduction

To build superior human resources, efforts need to be made to accelerate the adaptation of education, especially higher education in Indonesia, so that it is able to compete globally. To achieve learning outcomes, an important factor that must be considered is the implementation of the learning process. The learning process must be carried out flexibly to facilitate continuing education, it can be done face-to-face, remotely including online, or a combination of face-to-face and long-distance (Peraturan Menteri Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia Nomor 53 Tahun 2023 Tentang Penjaminan Mutu Pendidikan Tinggi, 2023). In reality, there are many obstacles to achieving the learning outcomes set out in SN Dikti. Many factors influence the ineffectiveness of learning outcomes, namely: the way the material is delivered, learning often involves giving too many assignments, which causes difficulties. Students experience a heavy learning load, the cultivation of character education is often neglected. (Chiu, 2022; Chung et al., 2020; Ms et al., 2022; Parwati & Suharta, 2020; Patricia Aguilera-Hermida, 2020; Sarfraz et al., 2022). In this digital era, all activities can be done digitally, including in the world of education. Therefore, online learning is a necessity.

However, in implementing online learning there are still many things that have not been properly prepared, for example infrastructure and human resources; online learning devices, such as learning media, learning platforms, which accommodate optimal student engagement. The engagement of student in learning means optimism and

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enthusiasm that students show when taking lessons (Bond et al., 2020; Paas & Van Merriënboer, 2020). This engagement can be seen from three aspects, namel behavioral, affective or emotional, and cognitive involvement. So far, online learning has not been implemented effectively. One of the reasons is that student involvement seems neglected. This can be seen from student learning outcomes that are not optimal, increased risk of dropping out of school, decreased motivation to learn, neglected development of student character and soft skills, as well as a learning environment that is not conducive (Chung et al., 2020; Kusuma et al., 2024). Another problem online is the delivery of material to students, students learning too much at once. Excessive load causes stress, physical and spiritual fatigue, and inability to concentrate. This causes students to forget important concepts which lead to failure in exams. The research results show that without direct and immediate teacher assistance in online learning, students do not have the ability to construct meaning and understand concepts independently. Based on this, student engagement in learning is very important to pay attention to (Hartnett, 2016).

The results of research examining student engagement in digital learning era have been carried out by several previous researchers. Research conducted by (Bond et al., 2020; Chiu, 2022; Heilporn et al., 2021; Zen et al., 2022) found that student involvement in learning still requires further study, especially in online learning. From several research results that have been presented, research specifically discusses empirical mapping of the application of student engagement-based learning in online learning and its impact on student learning outcomes, as well as examining the characteristics of student engagement-based learning in online learning has not been widely done.

In Hybrid-Flexible (HyFlex) learning, students are given complete control over their decision to participate online or in class. This gives them the ability to make participation choices based on convenience, pace of learning, engaging in social interactions, or other factors that are important to them at that time. On the other hand, educators must provide online and in-class learning experiences that support student learning. A bimodal approach with the learner's freedom to choose the mode is an important factor of the HyFlex design (Beatty, 2019; Chen, 2022). The characteristics of learning in the HyFlex class, depending on the context and content presented. Each HyFlex implementation has challenges and opportunities that require specific solutions to address. There are four important aspects that must be met for effective learning implementation, including: 1) managing a multi-modal learning environment, 2) workload, 3) interaction between students and educators, and 4) assessing learning progress. In the HyFlex class, an instructor/educator must have the ability to carry out online learning, which previously might have only focused on offline classes (Caparas & Yango, 2023). Synchronous learning in the HyFlex settings involves a set of tasks and skills that are largely similar to those used in classroom instruction, but are completely mediated through technology. For example: web meetings and webinars, such as: Gmeet, Zoom, Webex, etc (Detyna & Koch, 2023). Based on the theoretical studies that have been presented, it can be concluded that the application of HyFlex learning cannot be denied in this digital era. To achieve optimal learning results, the learning process in an online atmosphere must pay attention to student involvement, cognitively, emotionally and behaviorally.

The purpose of this study is to present an empirical synthesis of the relationship between student engagement and learning outcomes in HyFlex learning through meta-analysis and supporting survey data, to identify the key characteristics of effective engagement-based HyFlex practices in various educational and cultural contexts. Student engagement can be seen from several aspects, namely: behavioral involvement, affective/emotional involvement, cognitive involvement. Preliminary research examining aspects of student engagement in learning has been conducted by several researchers (Bond et al., 2020; Chiu, 2022; Heilporn et al., 2021; Zen et al., 2022). The results of the research that has been carried out show that from several of these research results, not many have studied in depth aspects of student engagement in online learning, as well as their impact on student learning outcomes. In addition, a literature review of HyFlex Learning research indicates that this field is growing and developing rapidly in line with the increasing demand for online learning. However, the positive and negative impacts of HyFlex learning remain unclear (Romero-Hall et al., 2025). Therefore, it is very urgent to carry out this research, which will produce theories and recommendations for implementing learning based on student engagement in HyFlex learning.

2. Research Method

This research uses two types of methods, namely meta-analysis methods and qualitative descriptive methods. This method is used in order to ensure methodological alignment with the theoretical framework of student engagement, which consists of three dimensions of behavioral, emotional, and cognitive engagement that form the conceptual basis for determining the focus of analysis in both stages of the research. In the meta-analysis, this theoretical framework was used as a guideline in identifying empirical studies that operationalized engagement as a predictor of learning outcomes in the context of online or HyFlex learning. The selection criteria, coding procedures, and effect size

calculations were developed based on the theoretical assumption that engagement is a multidimensional construct that influences academic performance. In addition, a descriptive qualitative design through surveys used the same theoretical dimensions to measure student engagement experiences in synchronous and asynchronous modes, so that the empirical results obtained directly reflected the conceptual model. The integration of both methodological approaches under the same theoretical framework ensured coherence between the research questions, theoretical basis, and empirical strategies. The research flow chart is as in Fig. 1.

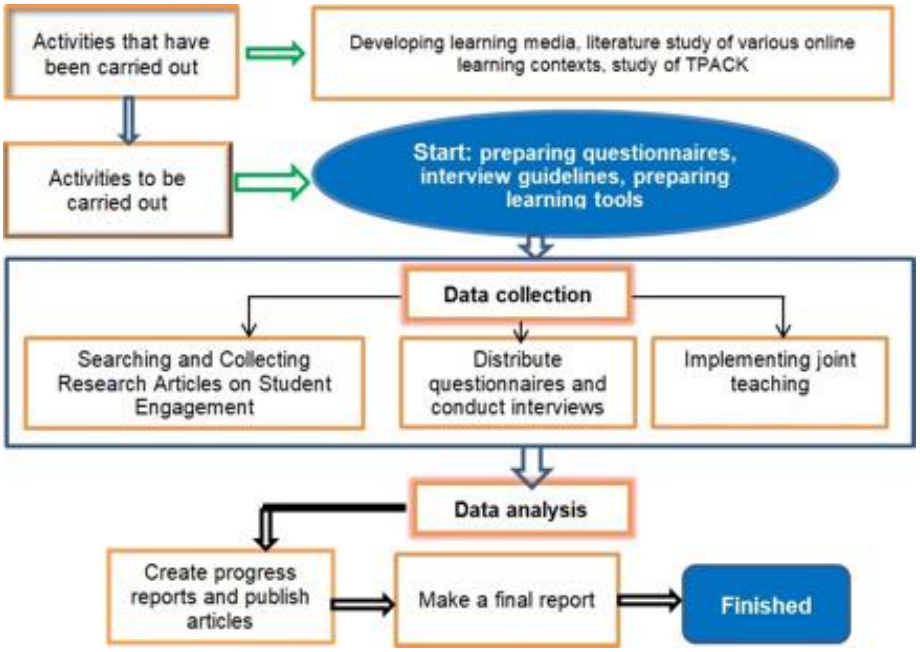

Fig. 1. Research Flow Chart

Meta-analysis is a systematic review method accompanied by statistical techniques to calculate conclusions from several research results (Abadi et al., 2023; Cohen et al., 2007). Meta-analysis as the statistical analysis of the collection of many individual research results as an integration of the findings. Judging from the process, meta-analysis is a retrospective observational study, in the sense that the researcher summarizes the facts without carrying out experimental manipulation. The meta-analysis planning process begins with 1) problem formulation, 2) data collection and assessment, 3) data analysis and interpretation and, 4) research report. At the filtering/sorting stage, the research activity is to filter articles based on inclusion criteria, namely articles that meet the criteria according to the topic to be studied and exclusion criteria, namely articles that do not meet the specified criteria. Inclusion and exclusion criteria can be described in Table 1.

Table 1. Inclusion and Exclusion Criteria

No	Inclusion Criteria	Exclusion Criteria
1	Speaks English, Malay, or Indonesia	Not in English, Malay, or Indonesia
2	Publicated on 2020-2023	Publicated before 2020
3	The results of empirical research are contained in reputable international journals and national journals indexed by SINTA 1 – 3, Scopus indexed proceedings, theses, and dissertations.	Non-empirical research results, articles in national journals that are not indexed by SINTA 1-3, seminar proceedings that are not indexed by Scopus, theses, books, papers/short reports, article in blogs.
4	The focus on study is on student engagement-based learning in online learning settings.	Student engagement-based learning in offline learing settings.

This research, conducted at Ganesha University of Education, Indonesia, will cover planning, implementation, data analysis, and reporting. We're collaborating with the University of Malaya, Malaysia, where joint teaching in research methodology courses will be used to empirically study student engagement in online learning. The research subjects were lecturers, students and education observers in two countries, Indonesia and Malaysia. Research subjects were determined using purposive sampling. The data collection techniques are Likert Scale questionnaires on student engagement in HyFlex Learning and reviews of relevant previous studies ultilized Publish or Perish (PoP) Software

(Miles et al., 1992). The data analysis in this study employed effect size calculation to address the research questions within the meta-analysis framework. The analysis was conducted using OpenMEE software for effect size computation and JASP software for generating Funnel Plots and validating publication bias. Interpretation of effect sizes followed established classification criteria. Descriptive statistical techniques were applied to quantitatve data from the questionnaire in order to assess the magnitude of HyFlex Learning's impact on student performance.

3. Results and Discussion

3.1. Meta Analysis Results

The article screening process aims to exclude articles that do not comply with the discussion of the research questions and established criteria. The main study selection process is carried out through four stages guided by PRISMA (Preferred Reporting Items for Systematic review and Meta Analysis), namely: (1) identification, screening, (3) eligibility, and (4) is included. The stages in filtering articles can be seen in Fig. 2.

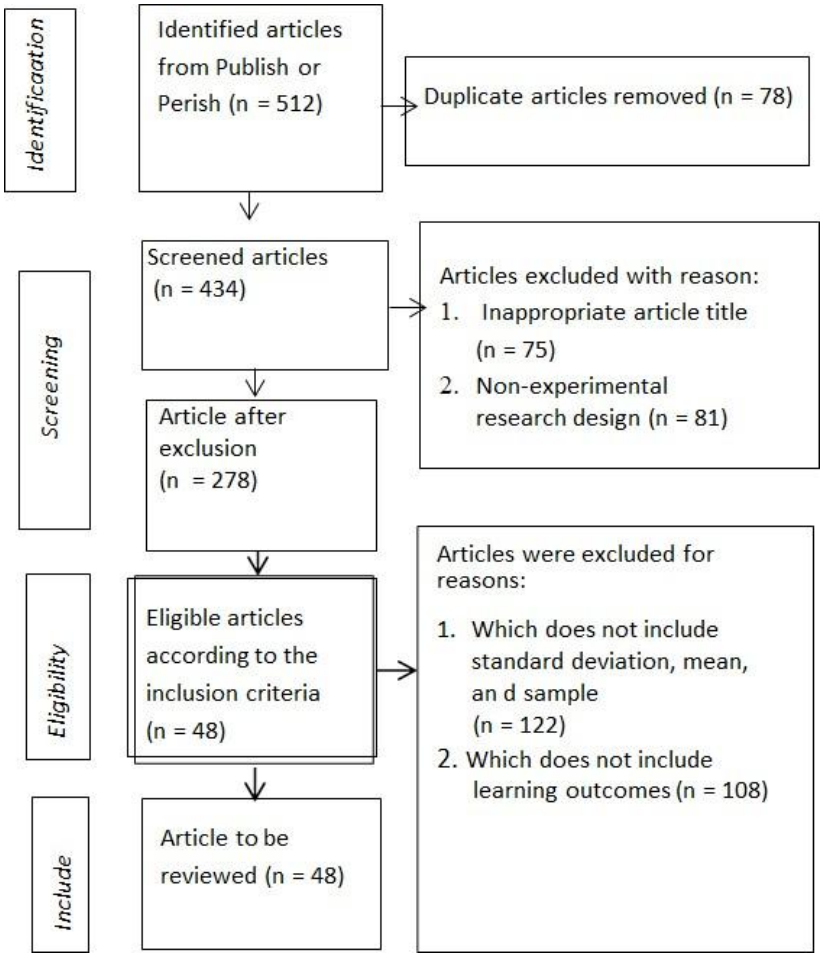

Fig. 2. PRISMA Flow Diagram

The search for articles utilized the PoP (Publish or Perish) software. In the initial search phase (based on the established inclusion criteria), 512 articles were identified. From 512 articles, 78 articles were removed due to duplication. Then, 434 articles proceeded to the screening stage, and 156 articles were removed because they did not meet the criteria, leaving 278 articles to proceed to the eligibility stage. At this stage, 230 articles were not eligible, resulting in 48 articles being forwarded for analysis in the meta-analysis stage. The meta-analysis stage used OpenMEE software to calculate the effect size and JASP software to generate funnel plots and validate publication bias. The effect size calculations are presented in Table 2. Based on the effect size calculation results, followed by calculating the Q statistical value using JASP software, the results are as shown in Table 3.

Table 2. Effect Size Measurement Results

Code	Ne	Xe	SDe	Nc	Xc	SDc	Level	Media	SE	ES
J1	37	95.5	4	37	86.9	3.47	SHS	LMS/VC/ Flipped	0.871	2.297
J2	32	66.875	13.545	32	54.0625	14.34	JHS	LMS	3.487	0.919
J3	14	76.78	3	14	65.35	1	ES	VC	0.845	5.112
J4	28	93	8.4	28	92.85	7.59	JHS	LMS GC, Zoom Meeting	2.139	0.019
J5	16	49.9	0.75	16	75.1	0.25	JHS	Blog	3.77	2.363
J6	120	80.5	0.175	120	78.6	0.05	JHS	GC, GF, Social Media	0.823	0.298
J7	28	62.14	8.69	28	87.14	6.879	ES	Blog	2.095	0.407
J8	43	73.05	12.01	43	80	62.7	SHS	VP and WA	9.735	0.154
J9	29	89.65	1.481	29	81.61	1.639	JHS	Schoology	0.41	3.295
J10	32	81.97	14.2093	32	69.37	18.52	VHS	Self eficience	4.126	0.763
J11	30	86.7	4.175	30	73.3	0.825	SHS	LMS	2.281	1.517
J12	35	81.71	6.75	35	73.71	3.25	SHS	GC	3.466	0.552
J13	33	81.26	4.695	33	65.18	2.076	SHS	Flipped	0.159	44.06
J14	63	77.5	4.66	63	70.71	4.32	JHS	Student worksheet	0.801	1.511
J15	36	91.37	3	36	66.57	1.75	JHS	Flipped, GC	0.579	10.1
J16	32	73.07	3	32	58.6	2.96	SHS	Schoology	0.745	1.206
J17	36	73.06	7.8	36	54.17	6.667	SHS	Flipped	1.71	2.603
J18	27	86.2	9	27	58.62	7.8	ES	WA	2.292	3.275
J19	30	75.8537	8.335	30	72.646	10.05	JHS	GC	2.384	0.347
J20	30	86.7	10.08	30	73.3	8.265	SHS	LMS	2.38	1.454
J21	80	96	7	80	80	2.5	ES	WA, VC	0.831	3.044
J22	30	81.44	11.303	30	58.11	19.11	JHS	GC	4.054	1.486
J23	40	75.81	11.453	40	75.54	4.41	ES	GC	1.94	0.031
J24	35	86.5	1.125	35	82	1.515	SHS	Edmodo	0.319	3.372
J25	376	85.31	15.48	441	77.53	7.53	JHS	GC	0.875	0.655
J26	25	85.41	5.975	25	76.1	3.648	JHS	LMS	1.4	1.881
J27	47	57.77	15.19	47	56.49	15.98	ES	GC	3.216	0.082
J28	30	89.05	3.75	30	55.56	3.5	VHS	LMS	0.937	9.233
J29	32	75.83	2.5	32	74.58	3	ES	GC	0.69	0.453
J30	22	78.64	6.58	22	26.14	7.858	ES	GC	1.812	8.802
J31	34	87.14	8.766	34	62.14	10.53	ES	ZOOM, GC	2.35	2.58
J32	24	96	4.417	24	81.25	6.417	ES	Blog	1.59	2.678
J33	31	77.66	0.8	31	73.5	0.75	JHS	GC	0.197	5.365
J34	35	79.17	8.33	35	91.67	9.167	JHS	ZOOM, GC	2.094	1.427
J35	38	89.06	16.14	38	70.01	13.92	JHS	GC, ZOOM	3.458	1.264
J36	23	47.82	0.33	23	52.18	0.83	SHS	ZOOM, GC	0.186	6.903
J37	37	80.76	3.432	37	71.66	11.05	SHS	GC, ZOOM	1.902	1.112
J38	39	76.78	8.9987	39	57.5	7.986	ES	ZOOM, GC	1.927	2.266
J39	14	25.1	4.14	14	75.1	1.678	ES	GC	1.194	15.83
J40	30	73.06	8.578	30	54.17	5.417	SHS	EFSZ	1.852	1.518
J41	28	96.43	0.146	28	35.7	0.148	JHS	Flipped	0.039	11.77
J42	20	24.6	3.58	20	12.7	4.88	SHS	LMS	1.353	2.781

Code	Ne	Xe	SDe	Nc	Xc	SDc	Level	Media	SE	ES
J43	25	55.24	5.17	25	23	3.4	Student	LMS	1.238	7.368
J44	58	85.63	5.12	64	26.98	12.56	SHS	MIIQ, Rivers state	1.708	0.616
J45	56	24.35	20.17	30	10.24	10.33	Student	Tik-tok	3.29	0.81
J46	97	37.7526	9.79055	97	28.134	11.06	SHS	LMS	1.5	0.921
J47	23	54.39	18.961	22	51.15	19.36	JHS	Student worksheet, LMS	5.715	0.169
J48	23	86.74	5.56	23	66.52	7.75	VHS	E-Book, LMS	1.989	2.998

Table 3. Fixed and Random Effects from Eligible Article

Fixed and Random Effects			
	Q	df	P
Omnibus Test of Model Coefficients	17.306	1	<0.001
Test of Residual Heterogeneity	45609.109	47	<0.001
Note. p-value are approximate			
Note. The model was estimated using Hedges method			

Based on the results of Fixed and Random Effects, from 48 study effect sizes analyzed are heterogeneous ($Q = 45609.109$; $p < 0.05$), this shown on Table 3. Given the high heterogeneity ($Q = 45609.109$, $p < 0.001$), a subgroup analysis was conducted to see whether education level (elementary school (ES), junior high school (JHS), senior high school (SHS), and vocational high school (VHS)) could explain some of the variation found. One-way ANOVA analysis showed in Table 4 indicates there is no significant differences between education levels (p=0.877). These results indicate that the relationship between student engagement and learning outcomes is relatively consistent across all education levels. These findings confirm that even though the study context is very diverse, the effect of student engagement on learning outcomes remains stable.

Table 4. One-Way ANOVA Results

ANOVA					
Effect_Size (ES)					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	33.491	3	11.164	.227	.877
Within Groups	2167.296	44	49.257		
Total	2200.787	47			

The random effect model is more suitable for estimating the average effect size of the 48 studies analyzed. The results also indicate that there is potential to investigate moderator variables that influence the relationship between student engagement and student learning outcomes. Meta-analysis using the JASP software, as shown in Table 5, produced z-values and p-values that indicate the influence of student engagement on learning outcomes. The results of the analysis with the random effect model show that there is a significant positive correlation between student engagement and student learning outcomes ($z = 4.160$; $p < 0.001$; 95%; [2.128; 5.921]. Thus, it can be concluded that there is an influence of student engagement on student learning outcomes in the high category.

Table 5. Random Effect Model Results

Coefficients						
					95% Confidence Interval	
	Estimate	Standar Error	z	p	Lower	Upper
Intercept	4.025	0.967	4.160	<.001	2.128	5.921

Note. Wald test

3.2. Publication Bias Analysis

The purpose of publication bias analysis is to ensure that meta-analysis results are not overly influenced by a tendency to publish only significant findings. Publication bias can occur when studies with insignificant results tend not to be published, thereby potentially distorting the overall effect size. To assess this, visual and statistical methods are used. First, a funnel plot (Fig. 3) is used to visually examine the distribution of effect sizes. The asymmetry in the plot indicates the possibility of missing studies. The Egger regression test (Table 6) is used to statistically test for this

asymmetry. A significant Egger test result ($p < 0.05$) indicates the potential for publication bias that needs to be considered when interpreting the meta-analysis findings.

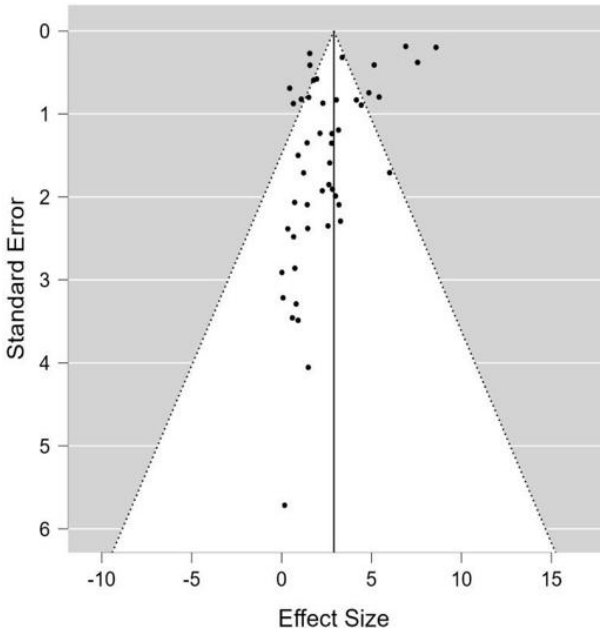

Fig. 3. Funnel Plot

Table 6. Egger's Test Results

Regression test for Funnel Plot Asymmetry ("Egger's test")			
		Z	**p**
sei		-1.356	0.039
File Drawer Analysis			
	Fail-safe N	Target Significance	Observed Significance
Rosenthal	15199.000	0.050	< .001

Based on the results of the egger's test, the p value was obtained = 0.039 <0.05. This states that the funnel plot is asymmetrical. Thus, it is concluded that there is publication bias in the meta-analysis study. However, these results cannot be fully trusted, therefore further testing was carried out using fail drawer analysis. For a value of K = 48 -1 = 47, using the Rosenthal formula, 5K + 10 = 5 (47) + 10 = 245 is obtained. The fail-safe N value obtained is 15199 with a significance level of 0.05, with $p < 0.001$, it can be seen that the fail-safe N value is > 5K + 10. Overall, the result suggests that although publication bias cannot be completely ruled out, the main conclusions of this meta-analysis remain stable. Hence, the impact of student engagement on learning outcomes should be carefully interpreted but can still be considered reliable.

3.3. Students Response

a) Response to student's engagement in online learning

To complement the results of the meta-analysis and to validate them in an authentic educational context, a student survey was administered involving a total of 124 respondents (110 from Indonesia and 14 from Malaysia). Due to the small number of Malaysian participants, the responses were combined into a single dataset for analysis. The demographic profile of the respondents is presented in Table 7, which shows that the participants represented a balanced distribution across gender, age groups, and study programs. The survey aimed to capture students' engagement experiences in HyFlex learning, focusing on both synchronous and asynchronous modes, as well as to identify the main factors influencing their engagement.

Table 7. Respondent Characteristics

Aspect		Country	
		Indonesia	Malaysia
Gender	Male	43	5
	Female	67	9
Age	<25 y.o	64	5
	25-35 y.o	17	8
	> 35.yo	29	1
Role	Educator	4	4
	Student	106	10

Table 8. Student's Engagement in Online Learning

Mode	Item	Score	Mean	Percentage
Synchronous	1	555	4.48	90%
	2	483	3.90	78%
	3	467	3.77	75%
	4	482	3.89	78%
	5	512	4.13	83%
	6	507	4.09	82%
	7	482	3.89	78%
	8	508	4.10	82%
Asynchronous	1	547	4.41	88%
	2	485	3.91	78%
	3	467	3.77	75%
	4	535	4.31	86%
	5	480	3.87	77%
Total		6510	4.03	81%

The survey results in Table 8 show that students generally reported high levels of engagement in synchronous HyFlex learning, with positive responses ranging from 75% to 90%. Active class participation (90%) reflects a strong level of behavioral engagement, as students actively interact in real-time discussions. Motivation to learn (78%) captures emotional engagement, showing that synchronous activities foster enthusiasm and persistence. Focus and concentration (75%) represent cognitive engagement, as students sustain mental effort despite the challenges of online learning. Connectedness with lecturers and peers (78%) indicates emotional and social engagement, highlighting the value of interpersonal interaction in maintaining involvement. Understanding lecture material (83%) demonstrates cognitive engagement, with synchronous instruction supporting comprehension through immediate feedback. Interest in presented material (82%) reflects emotional engagement, as students perceive content as appealing and stimulating. Becoming more active in learning (78%) illustrates behavioral engagement, where synchronous delivery encourages participation and initiative. Support in achieving learning goals (82%) combines cognitive and emotional engagement, suggesting that synchronous HyFlex contributes both to academic achievement and student confidence.

In asynchronous HyFlex learning, students also reported positive engagement, ranging from 75% to 88%. Accessing materials frequently (88%) reflects behavioral engagement, as students demonstrate consistent participation outside scheduled class hours. Motivation to learn while working on materials (78%) indicates emotional engagement, showing that independent study can still foster enthusiasm. Ease of understanding materials (75%) demonstrates cognitive engagement, as students process content at their own pace. Support for completing assignments (86%) combines cognitive and behavioral engagement, highlighting how asynchronous resources facilitate task completion. Help in understanding subject concepts (77%) underscores cognitive engagement, with flexible materials supporting deeper learning.

Overall, in both the synchronous and asynchronous modes, HyFlex learning showed a high level of engagement with an average of 81% positive responses. Synchronous mode primarily encourages behavioral and emotional engagement through active participation, direct interaction, and learning motivation. Meanwhile, asynchronous mode puts more focus on behavioral and cognitive engagement through flexible access to materials, independent learning, and support in completing assignments. This pattern is in line with the results of a meta-analysis that shows a positive and significant relationship between student engagement and learning outcomes. Thus, the survey data provides contextual

evidence that reinforces the conclusions of the meta-analysis. This confirms that student engagement, whether cognitive, emotional, or behavioral, is an important factor in optimizing learning outcomes in a HyFlex learning environment.

b) Factors Affecting Student Engagement in Online Learning

Respondents' opinions regarding factors affecting online learning were collected using a questionnaire with five options, namely: 1 = Very Unaffected until 5 = Very Affected. The results of the questionnaire are presented in Table 9.

Table 9. Respondent's Opinion

No	Statement	Responses Options					Mean	%
		1	2	3	4	5		
1	Quality of learning materials	2	1	12	59	50	4.24	85%
2	Learning methods used	1	1	9	47	66	4.41	88%
3	Learning media used	1	0	9	52	62	4.40	88%
4	Interaction with lecturers	1	1	9	41	72	4.45	89%
5	Interaction with classmates	3	3	11	56	51	4.18	84%
6	Learning atmosphere	2	3	7	38	74	4.47	89%
7	Learning facilities	1	3	12	52	56	4.31	86%
8	Self-learning motivation	1	1	7	41	74	4.51	90%
9	Self-discipline	1	2	11	33	77	4.46	89%

In addition to mode-specific responses, the survey also explored broader factors influencing engagement (Table 9). Students reported that the most influential factors included interaction with lecturer (89%), learning atmosphere (89%), self-motivation (90%) and self-discipline (89%). These results highlight that while HyFlex design provides flexibility, student engagement is shaped not only by instructional design but also by social interaction and personal responsibility in learning.

3.4. Discussions

This study provides strong evidence for the central role of student engagement in HyFlex learning. The meta-analysis of 48 studies demonstrated a positive and significant association between engagement and learning outcomes, confirming that engagement is a key predictor of academic success. Although substantial heterogeneity was present, subgroup analyses based on education level indicated no significant differences, suggesting that the effects of engagement are consistent across contexts. As commonly noted in meta-analytic research, publication bias may inflate effect sizes because studies with significant results are more likely to be published (Bond et al., 2020; Kusuma et al., 2024; Sarfraz et al., 2022). In this study, Egger's test suggested potential publication bias; however, the fail-safe N analysis showed that the findings remained stable and reliable. The survey results further supported the meta-analytic evidence, with 81% of students reporting positive engagement in both synchronous and asynchronous modes (Table 8). Additionally, interaction with lecturers and peers, learning atmosphere, self-motivation, and self-discipline emerged as the strongest contributors to engagement, each receiving scores above 85% (Table 9). Together, these findings highlight that optimizing learning outcomes in HyFlex environments requires not only effective instructional design but also supportive social interaction and strong learner self-regulation.

The results of this study align with previous research indicating that student engagement is a primary predictor of learning outcomes. The meta-analysis findings are consistent with prior evidence showing that engagement positively correlates with achievement across different education levels in HyFlex settings (Doo & Kim, 2024) . This pattern is further supported by studies demonstrating that higher engagement reflected in active participation and increased motivation to access learning materials in both synchronous and asynchronous modes is associated with better learning outcomes (Lin et al., 2019).

Previous research in Malaysia reported high levels of student engagement, particularly in behavioral aspects such as regular attendance and motivation to learn, while also emphasizing the importance of peer interaction and consultation with instructors (Hanefar et al., 2024). These findings align with the quantitative results of this study, where respondents demonstrated high levels of activity and confirmed that learning interaction is a crucial factor in

strengthening engagement within HyFlex environments. Other studies have shown that student autonomy, supported by the need for interaction in learning, significantly influences engagement and contributes to improved learning outcomes (Bozan et al., 2024; Dahleez et al., 2021). Although HyFlex research has expanded rapidly since 2018, much of the existing work has focused on technological support and infrastructure for HyFlex learning management (Wong et al., 2023). In contrast, this study identifies a broader set of key factors that optimize student engagement and thereby enhance learning outcomes in HyFlex settings.

The meta-analysis and survey findings complement each other in explaining the role of student engagement in HyFlex learning. The meta-analysis of 48 studies confirmed a significant positive association between engagement and learning outcomes, with consistent effects across education levels. In parallel, the student survey (N = 124) provides a clear depiction of how engagement is experienced in practice. High levels of active participation (90%), material comprehension (83%), and access to and support from asynchronous resources (88% and 86%) indicate that both synchronous and asynchronous modes are capable of sustaining strong engagement. Moreover, interaction with lecturers (89%), learning atmosphere (89%), self-motivation (90%), and self-discipline (89%) highlight the central role of cognitive, emotional, and behavioral engagement. Taken together, these findings demonstrate that HyFlex learning is both statistically effective and practically relevant in strengthening student engagement, which ultimately supports improved learning outcomes.

The findings of this study reinforce and extend the theoretical model of student engagement, particularly the behavioral, emotional, and cognitive dimensions identified in prior literature (Bond et al., 2020; Chiu, 2022). The significant overall effect size in the meta-analysis demonstrates that these three dimensions consistently predict learning outcomes across varied contexts and education levels. This supports existing theoretical assumptions and further shows that the stability of these engagement dimensions persists in flexible learning environments where students exercise autonomy over learning modes, including blended and other flexible formats (Song & Lai, 2025). Student engagement is also understood as a dynamic construct shaped by the interaction between learner autonomy, platform design, and the instructional context applied in flexible learning settings (Ayanwale et al., 2025). The survey results strengthen this model by providing empirical evidence that synchronous engagement is primarily characterized by behavioral and emotional indicators, whereas asynchronous engagement more strongly reflects cognitive processes. Together, these patterns clarify how engagement operates differently across learning modes and refine current theoretical understandings of engagement in flexible learning environments.

The results of this study also challenge and refine assumptions based on Cognitive Load Theory. Each individual is assessed as being able to accept different levels of cognitive load according to the quality of the content being studied and how that content is delivered to learners (Dewi et al., 2025). Although previous studies have claimed that online learning can increase external cognitive load due to unfamiliar technology or task overload, our findings show that well-structured asynchronous material can actually reduce cognitive load by allowing students to process information at their own pace (Skulmowski & Xu, 2022). The high positive responses regarding understanding of the material (83%) in synchronous learning and support for task completion (86%) in asynchronous mode indicate that HyFlex design, if well structured can reduce cognitive load rather than exacerbate it. This is also relevant to the statement that appropriate instructional design can reduce cognitive load in online learning (Costley, 2020). This suggests that the HyFlex model may encourage a re-evaluation of how cognitive load operates in flexible digital learning environments.

This study contributes to HyFlex learning theory by providing quantitative evidence that engagement remains a stable predictor of learning outcomes, regardless of the learning mode chosen by students. Although previous studies emphasize the importance of flexibility, few empirically demonstrate that engagement functions consistently across learning modes (Detyna & Koch, 2023). Furthermore, the study also shows that student engagement is influenced by content relevance, the quality of teacher-student interactions, support from educational institutions, and instructional design (Suartama et al., 2024). Our meta-analysis findings that educational level does not moderate the relationship between engagement and outcomes indicate that the multimodal structure of HyFlex does not diminish the theoretical centrality of engagement. In contrast, it highlights that meaningful interaction, regardless of the learning mode, is the fundamental mechanism that drives learning effectiveness in a HyFlex environment. Thus, in HyFlex learning, flexible learning modes do not diminish the importance of engagement. Therefore, theoretically, HyFlex must recognize that meaningful interaction remains the key to successful learning.

The findings of this study show both similarities and significant differences with the implementation of HyFlex in education systems applied in various regions. Similar to the case in Indonesia, studies in Malaysia report that student engagement is greatly influenced by interactions with lecturers and collaboration among classmates, although

Malaysian students tend to show higher levels of behavioral engagement due to better digital readiness and stronger institutional support (Chung et al., 2020; Hanefar et al., 2024). On the other hand, HyFlex studies conducted in Western contexts, such as the United Kingdom and the United States, emphasize student autonomy, technological effectiveness, and digital equity as the main factors determining engagement (Detyna & Koch, 2023; Beatty, 2019). In addition, the desire to study online, which is a growing trend in the United Kingdom, has emerged as one of the theories that can influence student engagement (Lowe et al., 2025). These systems generally have more mature HyFlex infrastructure, which may reduce external barriers but increase demands on self-directed learning. Despite these contextual differences, our meta-analysis and survey findings are consistent with global evidence showing that strong interactions or relationships between educators and learners and high levels of learning motivation are strong predictors of engagement and learning outcomes across learning modes. (Li, 2021).This implies that although Indonesia faces unique infrastructural and pedagogical challenges, the core mechanisms underlying successful HyFlex learning are consistent with international patterns, thereby reinforcing the global relevance of this study.

This study directly address the objectives formulated in the introduction, namely to present an empirical synthesis of the relationship between student engagement and learning outcomes in the context of HyFlex Learning. A meta-analysis of 48 studies shows that student engagement has a positive and significant effect on learning outcomes, and is consistent across various levels of education. These results are reinforced by a student survey which shows that an average of 81% of respondents responded positively to HyFlex learning, both in synchronous and asynchronous modes. In synchronous mode, active participation in class discussions (90%) and understanding of the material (83%) emphasized the importance of behavioral and cognitive engagement. In asynchronous mode, frequency of access to materials (88%) and support in completing assignments (86%) demonstrated the strong contribution of behavioral and cognitive engagement in supporting independent learning. In addition, broader factors such as interaction with lecturers (89%), learning atmosphere (89%), self-motivation (90%), and self-discipline (89%) underline the role of emotional engagement and self-regulation as key determinants of flexible learning success. Thus, this study not only reinforces the theoretical evidence that engagement is a key predictor of learning outcomes, but also provides practical recommendations that HyFlex design needs to emphasize interaction, a supportive learning atmosphere, and the facilitation of student motivation and self-discipline.

These findings also have practical implications for mathematics educators who integrate social-emotional learning (SEL) into HyFlex or online teaching. First, mathematics educators can design structured opportunities for positive interactions, such as collaborative problem-solving spaces, reflection sessions, or peer explanation cycles, to strengthen students' emotional engagement and sense of belonging, which in this study proved to be one of the strongest predictors of learning engagement. Second, Mathematics teachers can implement practices that support motivation, such as providing autonomy in task selection, offering alternative solution paths, and using real-world contextual problems to foster intrinsic motivation, in line with the SEL dimensions of self-awareness and motivation. Third, educators can explicitly support self-regulation by providing guided learning plans, weekly progress dashboards, or cognitive prompts that help students monitor their understanding, especially in asynchronous modes where cognitive engagement dominates. These strategies are consistent with our survey findings and meta-analysis evidence, and support the integration of SEL elements that facilitate sustained engagement and better mathematics learning outcomes in flexible learning environments. However, the limitations of this study remain in the diverse definitions of engagement and learning outcomes in the analyzed studies, as well as the lack of comprehensive moderator testing. Further research is needed to explore more specific contextual factors, thereby clarifying the optimal conditions for the effectiveness of HyFlex Learning. Thus, this study contributes both theoretically and practically to the development of engagement-based learning in the era of digital education.

4. Conclusion

This study aims to present an empirical synthesis of the relationship between student engagement and learning outcomes in HyFlex learning through meta-analysis and survey data support, while identifying the main components of effective engagement-based HyFlex learning practices. The meta-analysis of 48 studies shows that student engagement has a positive and significant effect on learning outcomes at various levels of education. Although Egger's test indicates the potential for publication bias, the fail-safe N analysis ensures that the meta-analysis results remain stable and reliable. This confirms that engagement is a major predictor of academic success in the context of HyFlex Learning. These findings are reinforced by the results of a student survey (N = 124), which showed an average of 81% positive responses to engagement in both synchronous and asynchronous modes. In synchronous mode, active participation in class (90%) and understanding of the material (83%) were the dominant indicators, while in asynchronous mode, regular access to materials (88%) and support in completing assignments (86%) were the main

determinants of engagement. Furthermore, broad factors such as interaction with lecturers and peers (89%), learning atmosphere (89%), self-motivation (90%), and self-discipline (89%) were the dominant factors supporting student engagement in learning to improve learning outcomes. Theoretically, this study enriches the literature by providing consistent evidence that student engagement is not only positively related to learning outcomes but is also influenced by a combination of instructional design, social interaction, and self-regulation. Practically, the results of this study provide recommendations for educators and institutions to design HyFlex Learning that emphasizes active participation, flexible access, meaningful interaction, as well as environmental support and student motivation and self-discipline. However, this study still has limitations, particularly regarding the diversity of definitions of engagement and indicators of learning outcomes in the studies analyzed, as well as the lack of in-depth testing of other moderating factors. Therefore, further research is needed to clarify the contextual conditions that most support the effectiveness of HyFlex Learning. Thus, this study provides empirical, theoretical, and practical contributions to the development of engagement-based learning in the era of digital education. In practical terms, the findings suggest that educators implementing HyFlex or online learning can enhance students' social-emotional engagement by fostering meaningful interaction, supporting intrinsic motivation, and providing explicit scaffolds for self-regulation.

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