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A HyFlex learning measurement model based on students' cognitive learning styles to create equitable learning

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Abstract

This article reports on a study that aims to develop and empirically test a measurement model of several constructs of cognitive learning styles, HyFlex learning modalities, and equitable learning with the assumptions of the indicators that build them. A total of 451 students from state universities and private universities in South Sulawesi, Indonesia, with previous online study experience, participated in the online survey. To investigate the interaction between cognitive learning style constructs and equitable HyFlex learning modalities, each used a set of indicators/items developed from Kirton's adaptation-innovation theory constructs, Felder-Silverman Learning Style with three HyFlex learning modalities, and equity pedagogy. Analysis of the measurement model was conducted using Smart-PLS software. The results of the measurement model analysis reveal the indicators that build the constructs of cognitive learning styles, HyFlex learning, and equity meet validity and reliability. The results of this study present alternative instruments to explain HyFlex learning constructs and indicators based on cognitive learning styles to create equitable learning in higher education.

Keywords: HyFlex learning, Kirton's cognitive theory, Felder-Silverman learning styles, equity pedagogy

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1. Introduction

Utilising the Flexible Hybrid design or multimodal course allows students to choose their learning modality and helps overcome the challenges inherent in Hybrid learning (Wilson & Alexander, 2021). The hallmark of this Flexible Hybrid course design is the HyFlex model (Beatty, 2007). HyFlex combines learning content offered in face-to-face and online modalities (Malczyk, 2019). Flexibility allows students to take part in learning through three modalities: face-to-face in class, online/virtual synchronous, online asynchronous, or a combination of the three modalities. Students can choose the HyFlex learning modality every week/topic based on their needs (Jongmuanwai et al., 2021) and pedagogical justice. This study uses a cognitive learning style approach for equitable learning to ensure that the HyFlex learning modality is by requirements and equity.

Previous studies conducted by researchers through literature studies, observations, and interviews show that the application of online learning and blended/hybrid learning still encounters significant problems in the choice of strategies and interaction methods, as well as learning content that does not meet the principles of learning style and equity. The results of the researcher's author's limited interviews with university students in Makassar, Indonesia, show that the content provided in face-to-face and online learning modes was not to the does meet the diverse needs of students. More specifically, students' choice of face-to-face or online learning modalities is only due to environmental conditions due to the COVID-19 pandemic and the main rules or instructions from lecturers are based on university policies. The choice of students is not based on their wants or needs. The study results provide a comparison that, on the one hand, students who attend face-to-face meetings many opportunities to interact with lecturers and other students.

On the other hand, students who participate in asynchronous online lectures often lack interaction opportunities and must bear all the responsibility for their learning (Heilporn & Lakhal, 2021). The results of another study revealed that since face-to-face classes were switched to an online format, the issue of justice was one of the victims of these changes, especially in terms of academic, psychological, and social consequences for students (Barrett, 2021). This suggests that investigating student needs and preferences in HyFlex modalities based on cognitive learning styles is very important to provide equitable learning opportunities.

Fundamental to the idea of HyFlex learning today and in the future are the needs, expectations, learning styles, and equity of student learning. This should always be the highest consideration before deciding on a HyFlex learning strategy/method. The literature study results confirm that HyFlex learning allows students to choose an appropriate learning style and environment for everyday learning (S. Esteron, 2021). However, one of the obstacles is the difficulty of identifying students' cognitive styles in online learning/HyFlex (Lo et al., 2012). At the same time, cognitive learning style is essential in choosing an online/HyFlex learning method that suits student needs (Huang et al., 2012; Ora et al., 2018). In this regard, awareness and understanding of HyFlex learning based on learning styles are the basis for realising learning equity for students. Equity HyFlex learning provides equal opportunities for students to learn according to their needs and the type of learning style (Hardaker et al., 2010) (Binnewies & Wang, 2019).

Early studies have emphasised the importance of research on the interaction of cognitive learning styles, HyFlex learning modalities, and equity learning. These three aspects have not received adequate attention and still pose severe problems for the current and predicted future implementation of online/hybrid/HyFlex learning. The issues related to of the three aspects tend to occur in students in other faculties or fields at universities in other countries. However, the study and observation of the fundamental problems described previously were obtained at universities in Indonesia. This research is essential to eliminate as many potential losses as possible when students choose one of the HyFlex learning modalities. Therefore, this initial research focuses on investigating the measurement model to obtain an instrument that can measure the interaction of HyFlex learning modalities by considering cognitive learning styles and equity.

Previous research has examined the visual-auditory-kinesthetic (VAK) learning style. Hybrid learning (Ora et al., 2018), social work in HyFlex blended learning with a student-centered approach (Malczyk, 2019), factors and needs assessment of HyFlex learning with a science base for critical thinking (Jongmuanwai et al., 2021), equity challenges and student engagement in HyFLex learning (Binnewies & Wang, 2019), students' perceptions of the HyFlex learning environment using the Cognitive of Inquiry method (Keiper et al., 2021), HyFlex adoption in higher education in response to COVID-19 from students' (Kohnke & Moorhouse, 2021), effective engagement strategy in HyFlex modality with cognitive method (Heilporn & Lakhal, 2021), HyFlex pedagogical challenges and opportunities (Miller et al., 2021), and others issues related to an equal and inclusive online classroom community during the COVID-19 Pandemic (Barrett, 2021). The results of previous studies indicate that HyFlex learning, cognitive learning styles, and equity have been the focus of researchers in several countries. Several previous studies have also used learning style instruments for the development and implementation of online/hybrid learning. This research extends the previous studies by developing a new instrument that uses and integrates a cognitive learning style theory approach with HyFlex learning and equity modalities, conducted in different locations and with different analytical methods.

This study investigates the interaction of three cognitive learning styles-based HyFlex learning modalities that have the potential to offer equitable learning for students. Specifically, this study aims to empirically develop and test a measurement model of several constructs of cognitive learning styles, HyFlex learning modalities, and equity learning, taking into account the indicators that build them. This study provides an alternative instrument to investigate and obtain information related to the HyFlex learning interaction model to realise equitable learning based on cognitive learning styles. More broadly, this research might assist future researchers interested in developing HyFlex education that is adaptive to equity online/hybrid learning issues.

This article is part of the national competitive basic research (for two years). In the first year, the HyFlex learning model instrument was developed and tested based on cognitive learning styles to create equitable learning by analyzing the measurement model. The second year produced a HyFlex learning interaction model for equitable learning through a structural equation model, strengthened by a qualitative descriptive analysis.

2. Theoretical Foundations

2.1 HyFlex learning

Unlike other hybrid or multimodal learning, in HyFlex learning, all learning modalities are mixed according to the preferences of the lecturer or learning designer. The HyFlex model allows students to choose which learning modality best suits their needs without compromising the quality and rigour of traditional face-to-face programs (Beatty, 2007; Wilson & Alexander, 2021). HyFlex learning offers students a choice per week/topic to attend class in one of three modalities: (1) face-to-face in class; (2) online/virtual synchronous with participants face to face via video conference using Zoom software, google meet, etc.; or (3) online asynchronous using independent learning resources at different times with face-to-face participants (Malczyk, 2019; Keiper et al., 2021; Wilson & Alexander, 2021; McCue, 2021).

Despite the advantages, HyFlex learning comes with two unique challenges. First, students must have equal/fair opportunities to learn from the three modalities and should not be disadvantaged by choosing one. Students must have equitable access to learning resources, tools to complete study assignments, and learning support according to their learning needs or cognitive style. Second, active learning strategies through feedback, responses, or collaborative activities carried out through face-to-face delivery often differ from strategies applied in the online delivery (Binnewies & Wang, 2019). Therefore, a measuring tool to investigate students' needs and preferences through a cognitive learning style approach and the choice of HyFlex learning modality is essential to research in order to realise equitable learning.

2.2 Cognitive Styles

Cognitive style is how a particular person perceives, perceives, and remembers (Hardaker et al., 2010). Cognitive style is an individual difference that refers to how individuals process and retain information, as well as how they prefer approaches to creative thinking, decision making, and problem-solving (Zamzuri et al., 2012; Lwande et al., 2021). In this study, the researchers used Kirton's adaptation-innovation theory (KAI) (Zamzuri et al., 2012). One approach to understanding and measuring cognitive style that has received much attention in the literature is based on Kirton's adaptation-innovation theory (Lwande et al., 2021). KAI is developed through two elements of adapter and innovator. Adapters describe individuals who do something better or quickly adapt a system. Meanwhile, innovators are individuals who like to do things differently or are more innovative in using a system (Zamzuri et al., 2012). Through the KAI theory, the tendency of students' cognitive learning styles in choosing the HyFlex learning modality will be known, whether it is in the category of adapter or innovator. This selection will provide information on the type of students' cognitive learning style, thus driving further studies to see the relationship between the three HyFlex modalities and the issue of equitable learning.

2.3 Learning Styles

Learning styles are considered part of cognitive styles, generally classified as centred on cognition, personality, or activity (Huang et al., 2012). Learning style is the preferred way of using students' abilities to learn (Rasheed & Wahid, 2021). In this study, the researcher considers four dimensions of the Felder-Silverman Learning Styles Model (FSLSM), namely: (1) input (visual/verbal), representing how students receive information; (2) perception (sensory/intuitive) related to student perception; (3) processing (active/reflective), representing how students process information; and (4) understanding (sequential/global) explaining the method of student understanding (Fida & Ghaffar, 2015; Heidrich et al., 2018; Rasheed & Wahid, 2021; Huang et al., 2012). FSLSM is used as it is considered more comprehensive than other famous learning style models (Huang et al., 2012). Another learning style model classifies students into several groups, FSLSM; FSLSM categorises student preferences into four dimensions with detailed descriptions of their characteristics. Precise measurement of learning styles is critical to identifying the relationship between learning styles and student preferences for HyFlex learning modalities. Therefore, the researcher considers that FSLSM provides the most appropriate measurement for studying the HyFlex learning modality, which can be employed to see the likes of the three modalities for equitable learning.

2.4 Equity

In this study, the justice in question is pedagogic justice which shows the method or learning style in choosing or using the HyFlex learning modality. More broadly, pedagogical justice can also be referred to as using correct learning strategies through the digital media (Hardaker et al., 2010). The strategy in question is flexible and structured in terms of implementing and delivering content through the HyFlex learning modality. Equity represents students' perceptions of equal learning opportunities field (Ahmed & Indurkhya, 2020).

Awareness and understanding of pedagogy based on cognitive learning styles are seen as the basis for equity in learning. The HyFlex learning modality provides various communication possibilities for all students, offers easy access to teaching materials, improves equity during the teaching and learning process, gives students the freedom to study independently with the desired modality, and improves quality by providing a technology-rich learning environment (Gulbahar & Madran, 2009). HyFlex learning offers a higher level of flexibility for education. Still, the challenge is to ensure that students are not disadvantaged regarding opportunities for interaction and knowledge acquisition (Binnewies & Wang, 2019) through the three HyFlex learning modalities. The transition to online delivery is a challenge exacerbated by equity. The ability of students and lecturers to accommodate the online environment is crucial. Equity is the central point for designing learning strategies (Murdoch et al.,

2022). Learning opportunities should be provided to meet student learning needs by understanding the context of HyFlex cognitive learning styles and modalities considered equity for HyFlex learning.

3. Methods

3.1 Participant, survey instruments, and data collection

The participants of this study were undergraduate students who had the experience of attending online/hybrid learning lectures at four State Universities and ten Private Universities in Indonesia. The survey instrument on HyFlex learning based on equitable cognitive learning styles was adapted and developed by looking at various literature on cognitive learning styles theory from KAI and FSLSM, HyFlex learning modalities, and equity pedagogy. Table 1 shows survey instruments developed and used in the research:

Table 1. HyFlex learning constructs to create equitable learning

Theoretical Support	**Constructs**	**Indicators/items**
Cognitive styles (KAI) *(Lomberg et al., 2017); (Bobic et al., 1999)*	Adaptor (Ad)	I think disciplined and careful in studying (Ad1)
		I prefer to look within the set rules (Ad2)
		I'm looking for a learning solution using a suitable and easy-to-apply method. (Ad3)
		I can focus on studying for a long time. (Ad4)
	Innovator (In)	I am interested in finding learning problems to solve(in1)
		I prefer learning that is not too bound by the rules (In2)
		I usually apply new ideas even though they have not been proven in finding learning solutions (In3)
		I do good study assignments quickly and intensively (In4)
Learning Styles (Felder-Silverman) *(Soloman et al., 1999) (Wang & Mendori, 2015); (Aljojo et al., 2015); (Graf et al., 2007)*	Active-Reflective (AR)	I understand learning something well once I try it (AR1)
		When my study group is working on challenging material, I tend to jump in and contribute ideas or discuss them (AR2)
		I know something well after I think about it and reflect on it (AR3)
		When my study group is working on challenging material, I tend to sit and listen/observe (AR4)
	Sensing-Intuitive (SI)	I prefer courses that emphasise concrete learning materials (based on facts and data) (SI1)
		I prefer to relate the material to the real world. (SI2)
		I prefer courses that emphasise abstract learning materials (based on concepts and theories) (SI3)
		I am more able to find possibilities and relationships and tend to be innovative and creative. (SI4)
	Visual-Verbal (VV)	I prefer to get new information in pictures, charts, graphs or maps (VV1)
		I am better able to remember well through studying by what I see (VV2)
		I like to get further details in written instructions or verbal information (VV3)
		I am better able to remember well what I hear (VV4)
	Sequential-Global (SG)	It is more important to me that a lecturer arranges the material in clear sequential steps. (SG1)
		When solving problems in groups, I will think of the steps in the solution-finding process. (SG2)
		It is more important to me that a lecturer gives the big picture and connects the material with other subjects. (SG3)
		When solving a problem in a group, I will think about the possible consequences or the application of the solution in a wide area. (SG4)
	Face-to Face	I always have face-to-face discussions on campus. (F2F1)
		I am interested in the demonstration method carried out in the classroom directly. (F2F2)
		Practicum/Laboratory I usually do learning on campus (F2F3)

HyFlex Learning *(Malczyk, 2019); (Heckman et al., 2015)*		I think the project-case-based method is better implemented in face-to-face classes (F2F4)
		I dare to ask questions or express opinions in face-to-face classes (F2F5)
	Online Synchronous	I prefer to be involved in lectures directly through video conferencing (OS1)
		I think Virtual Lab can support synchronous (live) online learning (OS2)
		I think the online presentation of project assignments is more flexible (OS3)
		I dare to ask questions or express opinions during lectures via video conference (OS4)
	Online Asynchronous	I am interested in having discussions in online forums through a learning management system (LMS) or other applications. (OA1)
		I watched the simulation/AR/VR videos provided (OA2)
		I read the provided e-book/module-based teaching materials (OA3)
		I can study anywhere and anytime (my study time is more flexible) (OA4)
Equity Pedagogy *(Hardaker et al., 2010); (Beatty, 2007)*	Equity	I think face-to-face HyFlex learning is more flexible and equitable to my needs. (Eq1)
		I think HyFlex learning through video conferencing gives me a fair measure with more flexible time according to my circumstances and needs. (Eq2)
		I think HyFlex learning via online asynchronous (discussion/video/simulation forums) is more flexible and equitable to my needs. (Eq3)
		I think combining the three modes of participation (Hybrid) can provide an equity learning experience according to my circumstances and needs. (Eq4)
		In my opinion, every student should have an equal/fair opportunity to access learning resources and participate in learning activities for all modes of participation. (Eq5)

Note: Using a four-point scale 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree, the constructs are to be measured by asking students to rate their perceptions of HyFlex learning in higher education

This study develops and validates a survey research instrument in a questionnaire, which assesses the HyFlex learning construct based on cognitive learning styles for equitable learning. There are several parts of the instrument. The first part is about student demographics such as gender and college. The second part consists of questions about the Adapter Innovator (KAI), sensing/intuitive, visual/verbal, active/reflective, sequential/global (FSLSM) factors on the HyFlex learning model (F2F, Online/virtual Synchronous, Online Asynchronous) and equity. All survey questions were designed on a 5-point Likert scale (5-strongly agree, 4-agree, 3-neutral, 2-disagree, 1-strongly disagree). To check the clarity and face validity, the questionnaire was tested on 30 students. The pilot test revealed no difficulties with words or understanding the question items. Therefore, no changes were made to the questionnaire.

Furthermore, the questionnaire was submitted to five experts (researchers and academics) for feedback. There have been several improvements of indicators/items in terms of substance and specific terms, which were made based on the experts' feedback. Subsequently, a full-scale survey was conducted. Two sampling methods were used, namely convenience sampling for determining universities and simple random sampling for determining students from the universities. However, the sample selection is also based on considerations of PLS-SEM analysis, which is 5-10 times the number of observation parameters (items/indicators) (Hair et al., 2010). Data collection was carried out from June to July 2022. The survey link was stored in the researcher's google form to be used to disseminate further surveys. A total of 451 participants responded to understand the constructs and indicators that build the HyFlex learning measurement model. Since data was collected via Google forms and all questions were answered, no information is lost.

Table 2. Sample characteristics

	Items	**Respondent**	**Percentage**
Gender	Male	136	30.16
	Female	315	69.84
Higher Education			
	State Universities	206	45.68

Private Universities	245	54.32

3.2 *SEM- Measurement Model Analysis*

This study uses a structural equation modelling (SEM) measurement model analysis with SmartPLS. SmartPLS is not based on many assumptions and can be used for very complex models. There are many latent and manifest variables without experiencing problems in data estimation. The measurement model tests the instrument's validity and reliability in SEM analysis (Jöreskog & Sörbom, 1993). The analysis of the measurement model in this study aims to test the validity and reliability of the instrument by looking at the relationship between indicators that build latent constructs of cognitive learning style, HyFlex learning, and equity.

Assessment of validity and reflective reliability was based on; (1) reliability indicators seen through the outer loading indicator value higher than 0.70 (Hair, 2017); however, the indicator/item is also said to be valid if it has an outer loading weight > 0.50 (Ghozali, 2014), and outer loadings less than 0.4 must be removed from the construction (Ketchen, 2013); (2) internal reliability consistency through composite reliability and Rho A. This study also did not use Cronbach Alpha because it tends to underestimate the reliability of internal consistency, composite reliability, and Rho A (Dijkstra–Henseler's ρ_A) more appropriate to use (Benitez et al., 2020); (3) Convergent validity through average variance extracted (AVE) must be higher than 0.50 (Hair, 2017), and (4) discriminant validity through Fornell-Larcker criteria and cross-loadings (Ringle et al., 2012; Hair 2017). Discriminant validity at indicator level with cross-loadings. The outer loading indicator for a construct must be higher than all cross-loadings for other constructs (Barclay et al. 1995; Hair 2017). At the construct level, discriminant validity was tested by comparing the square root of a construct's AVE with the construct's correlation with other constructs. Specifically, the square root of the AVE of each construct must be higher than the correlation between the different constructs (Fornell & Larcker, 1981).

4. Analysis and Results

The analysis of the reflective measurement model presented in Table 3 shows that the outer loading value for each item/construct indicator is above the minimum value of 0.60. However, five items had outer loading greater than 0.6 (Ad2, Ad3, Ad4, FF3, and Eq5) but did not reach a value of 0.70. This item is not omitted because an external loading between 0.40 and 0.70 should be considered for removal only if removal leads to an increase in composite reliability and AVE above the recommended threshold value (Hair Jr. et al., 2017). Internal consistency values between 0.6 and 0.7 are acceptable for the exploratory research (Hair, 2017). We chose a minimum default value of 0.6. Therefore, items showing outers loading less than 0.6 should be excluded from construction. There are two items/indicators marked "out" (See Table 2 column outer loadings). The items were banned because they tend to lead to an increase in composite reliability and AVE. A satisfactory internal consistency value above 0.7 is obtained because it is at 0.7–0.9 (Nunnally & Bernstein, 1994). This criterion is also used for Rho A and composite reliability. All constructs are reliable based on composite reliability and the value of Rho A constructs. Convergent validity is indicated by AVE. The analysis results in Table 3 show that all AVEs are higher than 0.50. The AVE value must be greater than 0.50 to account for more than half of the indicator variance (Hair Jr. et al., 2017).

Table 3. The results of the analysis of the reflective measurement model

Construct/Factors	Item	Outer Loadings	RhoA	Composite Reliability (CR)	Average Variance Extracted (AVE)
Adaptor	Ad1	0.826	0.701	0.804	0.508
	Ad2	0.640			
	Ad3	0.695			
	Ad4	0.678			

Innovator	In1	0.808	0.748	0.856	0.665
	In2	*out*			
	In3	0.814			
	In4	0.769			
Active-Reflective	AR1	0.804	0.817	0.890	0.729
	AR2	0.819			
	AR3	0.877			
	AR4	*out*			
Sensing-Intuitive	SI1	0.756	0.797	0.859	0.604
	SI2	0.745			
	SI3	0.757			
	SI4	0.847			
Visual-Verbal	VV1	0.721	0.745	0.839	0.566
	VV2	0.745			
	VV3	0.774			
	VV4	0.768			
Sequential-Global	SG1	0.737	0.84	0.876	0.639
	SG2	0.868			
	SG3	0.732			
	SG4	0.850			
Face-to-Face	FF1	0.744	0.846	0.878	0.591
	FF2	0.848			
	FF3	0.641			
	FF4	0.803			
	FF5	0.793			
Online Synchronous	OS1	0.850	0.845	0.895	0.682
	OS2	0.842			
	OS3	0.821			
	OS4	0.789			
Online Asynchronous	OA1	0.855	0.854	0.901	0.695
	OA2	0.869			
	OA3	0.861			
	OA4	0.743			
Equity	Eq1	0.793	0.863	0.895	0.632
	Eq2	0.852			
	Eq3	0.813			
	Eq4	0.841			
	Eq5	0.660			

Note: The value of loading items marked "out" is excluded because they do not meet the criteria >0.6.

Furthermore, discriminant validity uses the criteria Fornell and Larcker (1981) dan Cross loading by comparing all loading items. The Fornell Larckel criteria are based on the AVE, the most popular validity measure used in PLS-SEM. For the reflective model, the AVE must be greater than the squared correlation to investigate the discriminant validity of the model (Mehmetoglu, 2021). Table 4 below shows the Fornell Larckell Criteria. All constructs in the model HyFlex have good discriminant validity.

Table 4. Descriptive, Correlation between Factors and Roots of AVE

	Mean	SD	AR	Ad	OA	Eq	F2F	In	SI	SG	OS	VV
AR	4.13	0.97	**0.854**									
Ad	4.81	0.83	0.621	**0.713**								
OA	4.00	0.85	0.538	0.591	**0.834**							
Eq	4.14	0.77	0.555	0.526	0.675	**0.795**						
F2F	4.13	0.85	0.648	0.601	0.56	0.578	**0.769**					
In	3.98	0.86	0.674	0.674	0.623	0.558	0.679	**0.815**				
SI	4.16	0.77	0.693	0.626	0.634	0.598	0.67	0.731	**0.777**			
SG	4.34	0.70	0.727	0.679	0.653	0.649	0.711	0.67	0.722	**0.799**		

OS	3.73	1.01	0.445	0.461	0.769	0.566	0.491	0.558	0.557	0.535	**0.826**	
VV	4.22	0.74	0.653	0.613	0.639	0.597	0.662	0.701	0.751	0.729	0.554	**0.752**

Note: Adaptor (Ad), Innovator (In), Active-Reflective (AR), Sensing-Intuitive (SI), Visual-Verbal (VV), Sequential-Global (SG), Face-to-face (FF), Online Synchronous (OS), Online Asynchronous (OA), Equity (Eq)

Table 5 below shows the cross-loadings of all indicators. All indicators show the highest load on each construct among all other constructs (Barclay et al. 1995; Hair 2017). Therefore, it can be concluded that all items/indicators used in this study met the criteria for good discriminant validity in the preparation of each construct.

Table 5. Cross loading indicator Latent variable

	AR	**Ad**	**Eq**	**F2F**	**In**	**OA**	**OS**	**SG**	**SI**	**VV**
AR1	**0.804**	0.520	0.478	0.547	0.551	0.432	0.369	0.614	0.575	0.567
AR2	**0.819**	0.497	0.416	0.522	0.556	0.452	0.368	0.585	0.576	0.512
AR3	**0.877**	0.570	0.523	0.587	0.587	0.491	0.400	0.659	0.621	0.592
Ad1	0.521	**0.826**	0.456	0.508	0.571	0.540	0.417	0.556	0.517	0.484
Ad2	0.365	**0.640**	0.319	0.321	0.354	0.351	0.291	0.431	0.413	0.403
Ad3	0.533	**0.695**	0.425	0.47	0.444	0.381	0.267	0.581	0.478	0.477
Ad4	0.367	**0.678**	0.282	0.391	0.452	0.384	0.322	0.355	0.369	0.383
Eq1	0.514	0.441	**0.793**	0.534	0.492	0.533	0.428	0.539	0.517	0.524
Eq2	0.484	0.453	**0.852**	0.497	0.493	0.558	0.482	0.523	0.498	0.487
Eq3	0.438	0.380	**0.813**	0.435	0.438	0.585	0.546	0.517	0.478	0.480
Eq4	0.455	0.433	**0.841**	0.470	0.458	0.564	0.467	0.538	0.481	0.478
Eq5	0.425	0.386	**0.660**	0.341	0.324	0.427	0.296	0.463	0.392	0.393
FF1	0.457	0.409	0.358	**0.744**	0.529	0.395	0.384	0.444	0.453	0.432
FF2	0.565	0.502	0.497	**0.848**	0.562	0.459	0.388	0.615	0.555	0.571
FF3	0.359	0.294	0.314	**0.641**	0.339	0.266	0.253	0.385	0.378	0.367
FF4	0.542	0.529	0.515	**0.803**	0.564	0.488	0.395	0.621	0.563	0.59
FF5	0.614	0.521	0.491	**0.793**	0.592	0.494	0.438	0.611	0.586	0.538
In1	0.630	0.591	0.453	0.565	**0.808**	0.512	0.421	0.588	0.638	0.605
In3	0.520	0.504	0.470	0.569	**0.814**	0.493	0.49	0.495	0.579	0.531
In4	0.586	0.555	0.441	0.525	**0.769**	0.520	0.452	0.558	0.571	0.580
OA1	0.431	0.442	0.587	0.45	0.518	**0.855**	0.75	0.525	0.516	0.534
OA2	0.467	0.550	0.599	0.455	0.511	**0.869**	0.630	0.548	0.522	0.516
OA3	0.473	0.511	0.554	0.448	0.492	**0.861**	0.635	0.550	0.539	0.536
OA4	0.489	0.463	0.506	0.513	0.563	**0.743**	0.545	0.554	0.536	0.544
OS1	0.394	0.355	0.479	0.383	0.449	0.650	**0.850**	0.434	0.483	0.477
OS2	0.415	0.401	0.469	0.437	0.465	0.629	**0.842**	0.455	0.467	0.449
OS3	0.367	0.332	0.461	0.374	0.433	0.580	**0.821**	0.377	0.407	0.420
OS4	0.440	0.429	0.458	0.424	0.509	0.675	**0.789**	0.495	0.479	0.480
SG1	0.503	0.507	0.460	0.466	0.373	0.388	0.293	**0.737**	0.491	0.511
SG2	0.708	0.607	0.593	0.671	0.614	0.614	0.488	**0.868**	0.663	0.633
SG3	0.476	0.425	0.472	0.484	0.454	0.427	0.381	**0.732**	0.514	0.538
SG4	0.622	0.608	0.536	0.615	0.614	0.607	0.507	**0.850**	0.614	0.632
SI1	0.578	0.506	0.441	0.517	0.537	0.445	0.362	0.552	**0.756**	0.590
SI2	0.607	0.418	0.440	0.455	0.504	0.402	0.338	0.550	**0.745**	0.589
SI3	0.501	0.477	0.436	0.476	0.565	0.521	0.481	0.490	**0.757**	0.546

SI4	0.624	0.535	0.532	0.617	0.654	0.577	0.521	0.646	**0.847**	0.618
VV1	0.480	0.482	0.482	0.525	0.538	0.492	0.452	0.524	0.601	**0.721**
VV2	0.556	0.446	0.412	0.484	0.457	0.416	0.333	0.561	0.515	**0.745**
VV3	0.502	0.446	0.443	0.463	0.516	0.510	0.413	0.565	0.549	**0.774**
VV4	0.539	0.467	0.453	0.515	0.567	0.496	0.456	0.544	0.586	**0.768**

Note: Adapter (Ad), Innovator (In), Active-Reflective (AR), Sensing-Intuitive (SI), Visual-Verbal (VV), Sequential-Global (SG), Face-to-face (F2F), Online Synchronous (OS), Online Asynchronous (OA), Equity (Eq)

5. Conclusion, Limitations, and Implications

This article presents a theoretical background that covers the main problems and challenges faced in HyFlex learning today and predicts the future related to needs and expectations, cognitive learning styles, and student learning equity. The measurement model proposes a cognitive learning style to indicate the preference of a suitable HyFlex learning modality for students and the students' preference for equitable learning based on the HyFlex learning modality. The measurement model was developed and then validated empirically based on the theory of cognitive learning styles, HyFlex learning modalities, and pedagogic equity. This study shows that all the indicators that build the construct meet the validity and reliability requirements. The results of this study present alternative instruments (see Appendix) to explain HyFlex learning constructs and indicators based on cognitive learning styles to realise equitable learning in higher education.

This study tested a limited instrument on students from 14 universities in Makassar City, Indonesia. The results may be different if students across cities and provinces across universities and students in schools are also included in this study. This study also did not map the participants' areas as samples. The discussion may be much more comprehensive if there is a mapping of regions such as rural or urban areas, plus the condition of the internet network and software used in this study. The study may look further/consider the issue of equitable learning in terms of regional demographics and accessibility.

This study provides a better understanding of about the development of the HyFlex learning instrument that considers the theory of students' cognitive learning styles more specifically; it is an instrument that can measure the potential for equitable learning through three HyFlex learning modalities, namely face-to-face, online/virtual synchronous and online asynchronous online. This study also has practical implications for lecturers and instructional designers; they should pay attention to or consider the HyFlex learning instrument to investigate the types of learning styles and tendencies of the HyFlex modality for equitable learning. In this way, the implementation and development of adaptive HyFlex learning among university students and lecturers will be realised and continue to increase.

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Appendix. The Valid and Reliable Research Instruments

Using a four-point scale of 1=strongly disagree, 2=disagree, 3= neutral, 4=agree, 5=strongly agree, the variables are to be measured by asking lecturers to rate their perceptions of the online learning system in higher education

Strongly disagree 1 – 2 – 3 – 4 - 5 strongly agree

Constructs	**Codes**	**Items/indicators**
	Ad1	I think disciplined and careful in studying

Adaptor (Ad)	Ad2	I prefer to look within the set rules
	Ad3	I'm looking for a learning solution using a suitable and easy-to-apply method.
	Ad4	I can focus on studying for a long time.
Innovator (In)	In1	I am interested in finding learning problems to solve
	In3	I usually apply new ideas even though they have not been proven in finding learning solutions
	In4	I do good study assignments quickly and intensively
Active-Reflective (AR)	AR1	I understand learning something well once I try it
	AR2	When my study group is working on challenging material, I tend to jump in and contribute ideas or discuss them
	AR3	I know something well after I think about it and reflect on it
Sensing-Intuitive (SI)	SI1	I prefer courses that emphasise concrete learning materials (based on facts and data)
	SI2	I prefer to relate the material to the real world.
	SI3	I prefer courses that emphasise abstract learning materials (based on concepts and theories)
	SI4	I am more able to find possibilities and relationships and tend to be innovative and creative.
Visual-Verbal (VV)	VV1	I prefer to get new information in pictures, charts, graphs or maps
	VV2	I am better able to remember well through studying by what I see
	VV3	I like to get further details in written instructions or verbal information
	VV4	I am better able to remember well what I hear
Sequential-Global (SG)	SG1	It is more important to me that a lecturer arranges the material in clear sequential steps.
	SG2	When solving problems in groups, I will think of the steps in the solution-finding process.
	SG3	It is more important to me that a lecturer gives the big picture and connects the material with other subjects.
	SG4	When solving a problem in a group, I will think about the possible consequences or the application of the solution in a wide area.
Face-to Face	F2F1	I always have face-to-face discussions on campus.
	F2F2	I am interested in the demonstration method carried out in the classroom directly.
	F2F3	Practicum/Laboratory I usually do learning on campus
	F2F4	I think the project-case-based method is better implemented in face-to-face classes
	F2F5	I dare to ask questions or express opinions in face-to-face classes
Online Synchronous	OS1	I prefer to be involved in lectures directly through video conferencing
	OS2	I think Virtual Lab can support synchronous (live) online learning
	OS3	I think the online presentation of project assignments is more flexible
	OS4	I dare to ask questions or express opinions during lectures via video conference
Online Asynchronous	OA1	I am interested in having discussions in online forums through a learning management system (LMS) or other applications.
	OA2	I watched the simulation/AR/VR videos provided
	OA3	I read the provided e-book/module-based teaching materials
	OA4	I can study anywhere and anytime (my study time is more flexible)
Equity	Eq1	I think face-to-face hyflex learning is more flexible and equitable to my needs.
	Eq2	I think hyflex learning through video conferencing gives me a fair measure with more flexible time according to my circumstances and needs.
	Eq3	I think hyflex learning via online asynchronous (discussion/video/simulation forums) is more flexible and equitable to my needs.
	Eq4	I think combining the three modes of participation (Hybrid) can provide an equal/fair learning experience according to my circumstances and needs.
	Eq5	In my opinion, every student should have an equal/fair opportunity to access learning resources and participate in learning activities for all modes of participation.

Note. The loading value of items marked "*out*" is excluded.