Investigating the Difference in Malaysian Undergraduates' Academic Achievement and Learning Interest across HyFlex Learning Modes

Liang Jing Teh, Su Luan Wong*, Mohd Zariat Abdul Rani, Mas Nida Md Khambari, Sai Hong Tang and Ahmad Sarji Abdul Hamed

***Abstract*—There is a lack of knowledge on the difference in Malaysian undergraduates' academic achievement and learning interest between physical (P), online synchronous (OS), and online asynchronous (OA) learning modes in Hybrid-flexible (HyFlex) lab sessions. Together with the inherent challenges of HyFlex learning, there is a need to conduct this study. This multimethod design study was conducted at a public university in Malaysia. The quantitative and qualitative strands of this study involved 65 and eight participants respectively. Multivariate analysis of variance showed no significant difference in students' academic achievement among the three learning modes whereas a significant difference in their learning interest was found between P and OA learning modes. Thematic analysis indicated that the multiple learning modes, mandatory learning evidence, instructor feedback, and students' priorities contributed to students' academic achievement across learning modes. The flexibility in learning enhanced students' overall learning interest. The physical presence of peers and instructors and students' familiarity with P learning also enhanced students' learning interest in the P mode. On the other hand, the feelings of disconnection and technical issues experienced by the students reduced their interest in learning in the OA mode. This study implies the opportunity for developing countries to expand access to education cost-effectively and enhance future leaders' digital literacy. Nevertheless, the findings also imply challenges such as time and financial constraints, the existing digital divide, and the potential resistance from traditional educators.**

***Index Terms*—HyFlex Learning, Academic Achievement, Learning Interest, University Students**

I. Introduction

Hybrid-flexible (HyFlex) learning offers flexibility by blending traditional in-person instruction with online learning options [1]. HyFlex learning accommodates diverse student needs and schedules by allowing them to choose between three learning modes, namely physical (P), online synchronous (OS) and online asynchronous (OA) participation [1]-[4]. This resonates with the Malaysia Education Blueprint for Higher Education (2015-2025) which aims to adopt blended learning models in more than half of the learning programs [5]. Although several scholars have examined the difference in academic achievement, previous works investigating students' learning interest in HyFlex learning are limited. The learning outcomes closest to learning interest which were commonly studied were learning satisfaction [6] and the perceived presence of Community of Inquiry (CoI) [7]. Additionally, research which specifically investigates students' academic achievement and learning interests in a HyFlex learning environment in Malaysia is currently scarce.

II. Literature Review

A few scholars have postulated that there was no significant difference in academic achievement between students across three learning modes [8]-[12]. The option to participate online is more beneficial for students than being absent from class [10]-[12]. Studies also concluded that HyFlex learning could promote overall learning satisfaction among students [1], [6], [9]. However, other scholars raised concerns about the fact that less motivated students might be lured by the flexibility of HyFlex learning to exploit online options [13]. Also, students could have different academic achievements and learning interests across different learning modes [1], [7]. This is mainly due to the difficulty in providing equal learning experiences to physical and online students [8], [4], technological issues [1], and students' self-management skills [13].

In Malaysia, a few scholars started investigating HyFlex learning post-COVID-19 pandemic. A pilot case study on undergraduates' learning experience with HyFlex culinary lab sessions indicated an enhanced overall student learning experience. The online options allowed learners to learn in their desirable ways and they could review their study through the recordings [14]. Despite the online environment, learners could interact with their peers and instructor in real-time. The HyFlex lab sessions also fostered self-directed learning among the students, which contributed to their academic achievement [14]. Another qualitative study suggested that

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students' learning experiences in HyFlex learning were affected by instructors' competence in managing OS and OA learning, as well as students' e-learning self-efficacy [15]. Additionally, a preliminary action research on the HyFlex teaching approach revealed that most students preferred P learning mode while using online materials mainly for revision [16]. Some students preferred face-to-face learning over blended mode due to concerns about the practical nature of the course [14], [15].

Further, technical disruptions such as video freeze and the need for students to exit and re-enter the online sessions affected learners' online experience [14]. These findings highlight the importance of enhancing online interactivity and understanding student barriers to the various learning modes in HyFlex learning. Given the lack of studies on HyFlex learning in Malaysia, there remains an ambiguity in the knowledge regarding the difference in student academic achievement and learning interest between different learning modes of HyFlex learning in the context of educational lab sessions at a Malaysian public university. Therefore, this study aims to contribute to the existing body of knowledge by answering the following research questions:

1. Is there a difference in students' academic achievement among P, OS, and OA learning modes in HyFlex lab sessions?
2. Is there a difference in students' learning interest among P, OS, and OA learning modes in HyFlex lab sessions?
3. What are the factors behind the difference or indifference in academic achievement and learning interest between the three learning modes in HyFlex lab sessions?

III. Methodology

A. Research Design

A multimethod research design was employed in this study. Quantitative data collection and analysis were first conducted and were followed by a qualitative phase of data collection and analysis to explore the factors behind the quantitative results. This design intended to utilize the qualitative phase to gain a deeper understanding of the quantitative findings.

This study was conducted in the faculty of education of a public university located in the central region of Malaysia. In the quantitative phase, criterion sampling was utilized to select participants. The inclusion criteria include undergraduate students who have: (1) enrolled in the course offered by the faculty of education and (2) completed the HyFlex lab sessions of the course. The categorization of learning mode groups among the students was based on the majority rule. For instance, if a student participated in the lab sessions physically the most, that student would belong to the P learning mode group in this study. The students with an equal number of participations for each learning mode were not included in the data analysis.

Among 74 undergraduate students who voluntarily submitted the online questionnaire in the quantitative study, 65 submissions (22 male and 43 female) were valid. As presented in Table I, eight participants with varying genders (four males and four females), age, learning mode preferences, and academic achievement were then heterogeneously sampled from the same group of students to participate in the focus group discussion (FGD). Maximum variation sampling was utilized to enhance the diversity of students' learning experiences. All data provided during the FGDs were held private and the participants' names were coded as shown in Table I.

TABLE I
Demography of FGDs' Participants

Student	Gender	Age	Learning mode	Academic achievement (per 70%)
#1	Male	21	Physical	59.8
#2	Male	22	Online synchronous	61.2
#3	Female	22	Physical	58.7
#4	Female	21	Online asynchronous	62.00
#5	Male	22	Online asynchronous	49.00
#6	Male	23	Online synchronous	51.25
#7	Female	23	Physical	51.80
#8	Female	21	Physical	55.00

The students' academic achievement was measured by using academic assignments, which took up 70% of their total score. Their perceived learning interest was measured by using a learning interest scale consisting of 18 items with a five-point Likert scale which was adapted from the situational interest scale developed by Chen et al. [17]. A pilot test among 30 students in the same faculty was conducted and a Cronbach alpha value of .85 was obtained, indicating that the learning interest scale's items had good internal consistency [18]. A FGD protocol was developed by the first author and was evaluated by the other authors before conducting the FGDs. No new themes emerged from the second FGD, indicating data saturation. Thus, two FGDs were conducted in this study. Semi-structured questions were used to guide the FGDs as they allow the researchers to collect accurate information aligned with research objectives while accommodating the exploration of new ideas [19].

Multivariate analysis of variance (MANOVA) was adopted to examine the difference in student's academic achievement and learning interest among P, OS, and OA learning modes. The authors decided to use the alpha value, $\alpha = .05$ as it is optimum for the quantitative analysis of this study [20]. All quantitative data analysis was conducted by using the IBM SPSS statistics version 26 software program. As for the qualitative strand, thematic analysis was used to analyse the transcript. The author obtained an overall impression of the data by reading and rereading the transcripts, this is followed by forming meaning units, codes, categories, and themes [21].

B. HyFlex Lab Sessions Implementation

The implementation of the HyFlex lab sessions was based on the guidelines provided by Wang and Huang [9]. The course of the lab sessions implemented in this study was Educational Technology. For each lab session, the students could choose to attend physically, join via an online conference call platform, or participate by watching the recorded session. The online conference call platform, Zoom, was used to conduct the online component of the HyFlex lab sessions. Fig. 1 illustrates the HyFlex lab session of the course. The HyFlex laboratory was equipped with high-speed internet, an overhead camera and wireless clip microphones to capture high-quality visuals and audio of both students and the instructor. As

shown in Fig.1, the online synchronous students' names and videos were displayed on the white screen to create a sense of togetherness between the physical and online synchronous students. The recorded sessions were uploaded into a cloud folder and shared with the students through the institution's learning management system.

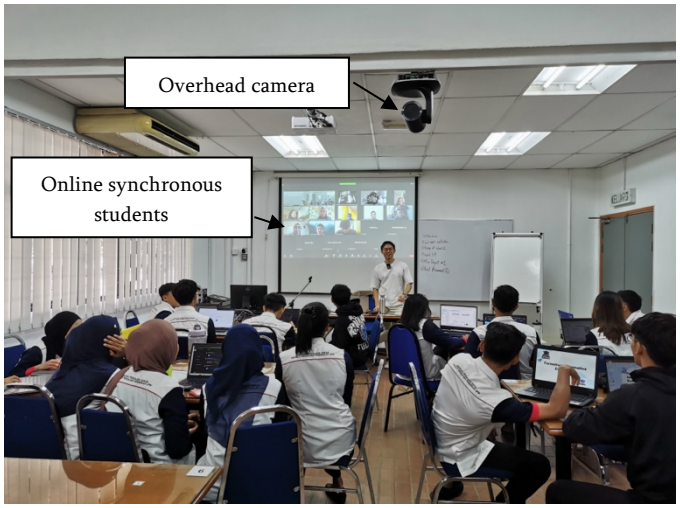

Fig. 1. HyFlex Lab Session of Educational Technology Course.

To control the implementor effects, the first author was the sole instructor of all lab sessions throughout the 14-week semester. The HyFlex learning model was integrated into the lab sessions for 12 consecutive weeks (from week two to week 13). During the first week of the semester, the instructor briefed the students on the ways of participating through the various learning modes of the HyFlex lab sessions and the expectations for online students such as switching on their web cameras and submitting learning evidence. The attendance for both online synchronous and asynchronous students was captured based on the submission of learning evidence, which includes digital quizzes, weekly reflections, and documentation of student's work.

IV. Results and Discussions

A. Quantitative Findings

The summary of findings obtained through MANOVA is shown in Table II. It shows that more than half of the students (55.38%) preferred P learning mode over OS and OA modes. As it was the students' first experience with HyFlex learning, they gravitated toward the learning approach which they were more familiar with. This result is consistent with previous studies which found that students were keener on P learning mode during the initial stages of HyFlex instruction [10], [11]. This signifies that learners in developing countries might face adaptation challenges in HyFlex learning. The students may prefer P learning as their primary learning mode and use the online modes as supplementary resources for reinforcing their knowledge [16]. However, with time and experience, their preferences may shift toward the flexibility provided by online learning modes [10], [11]. This also indicates that adequate support and time for adaptation should be provided for students to allow them to embrace the diverse options available within HyFlex learning.

1) Difference in Student's Academic Achievement among P, OS, and OA Learning

The overall academic achievement mean scores were moderately high for all three learning modes. This indicates that students can perform well in a HyFlex learning environment. An insignificant difference in students' academic achievement was found between the three learning modes $F(2, 62) = 1.53$, $p > .05$. These findings resonate with the results of several previous studies which showed no significant difference in academic grades between students from different learning modes [8]-[12]. These results signify that the students across the three learning modes received adequate and equivalent support and guidance throughout the HyFlex lab sessions. This also suggests that students' academic achievement may be influenced by teaching strategies, self-efficacy in e-learning, and accessibility of learning resources rather than the learning modes [15]. Intriguingly, although not significant, the mean academic achievement in Table II shows that the online students performed slightly better than the face-to-face students. This result is in line with a few previous works which showed that the online students performed better than the in-person students [10], [11]. This implies that OS and OA learning modes can offer advantages such as autonomy in learning pace and access to diverse resources. This also reflects the growing adaptation of students to e-learning platforms.

The findings show HyFlex learning's potential in addressing the common challenges in developing countries such as logistical barriers and limited access to educational institutions. The online options within HyFlex learning could increase access to education, especially for students in rural areas. HyFlex learning could reduce their financial burden in terms of transportation and accommodation. This contributes to bridging educational gaps in underserved regions. Therefore, educational stakeholders and the government in developing nations should collaborate with the private sectors and nongovernmental organisations (NGOs) to expand internet coverage, provide cost-effective e-learning solutions, as well as develop instructors and students to become well-versed in HyFlex instruction.

TABLE II
Summary Results of MANOVA Comparing Academic Achievement and Learning Interest among Learning Modes

Variable	n (%)	Mean	SD	F	p	η^2
Academic achievement				0.135	.874	.004
Physical	36 (55.38)	80.27	3.32			
Online synchronous	15 (23.08)	80.87	4.70			
Online asynchronous	14 (21.54)	81.04	3.60			
Learning interest				3.151	.049	.092
Physical	36 (55.38)	4.55	0.37			
Online synchronous	15 (23.08)	4.35	0.54			
Online asynchronous	14 (21.54)	4.25	0.34			

2) Difference in Student's Learning Interest between P, OS, and OA Learning

The overall learning interest mean scores were high for all three learning modes, this suggested that the students were generally interested in learning in a HyFlex learning setting despite the various learning modes. However, a significant difference was found in students' learning interests among the three learning

modes F (2, 62) = 3.15, p < .05. Thus, a pairwise comparison using Bonferroni adjustment on learning interest between P, OS, and OA was conducted and is presented in Table III. Based on Table III, there was an insignificant difference in learning interest between the P and OS groups as well as between the OS and OA groups. However, a significant difference was found between the P and OA groups. These findings are in line with previous studies which postulated that there can be a difference in learning experience between in-person and remote learners [4].

The undergraduate students were more motivated when learning synchronously as compared to learning via OA mode. OS learning could mirror the real-time interaction found in P learning which helped maintain similar levels of learning interest. This suggests that OS learning can provide a compelling alternative to traditional classrooms in developing countries [14]. The lower learning interest among the OA students may be due to lower OA learning self-efficacy [15] as well as the lack of immediate interaction and peer collaboration. This also explains the students' stronger preferences towards P learning mode as shown in Table II. Hence, it is pertinent to integrate interactive elements into OA learning modes to retain students' interests. When implementing HyFlex learning, the curricula need to be redesigned to ensure that the instruction caters to OA students' needs. Moreover, regular evaluation of the implementation of HyFlex learning needs to be conducted. Students' and instructors' voices should be heard to constantly improve the implementation of HyFlex learning in developing countries, especially in terms of student engagement in OA learning mode.

TABLE III
COMPARISONS OF LEARNING INTEREST AMONG LEARNING MODES

(I) Learning mode	(J) Learning mode	I-J	SE	p
Physical	Online synchronous	.201	.126	.115
	Online asynchronous	.298	.129	.024
Online synchronous	Physical	-.201	.126	.115
	Online asynchronous	.097	.152	.525
Online asynchronous	Physical	-.298	.129	.024
	Online synchronous	-.097	.152	.525

B. Qualitative Findings

Through thematic analysis of the FGD's transcript, a few themes emerged regarding the similarity in academic achievement and the significant differences in learning interest among the three learning modes. The themes are described in the following sub-chapters.

1) Multiple learning modes improve student academic achievement

The students' sharing shows as if the main reason why the undergraduate students gained similar academic grades was because of the various learning mode options available. The ubiquitous learning materials such as the recordings allowed the learners to learn according to their pace. Their autonomy in choosing learning modes enabled them to fit their learning to their preferences, as stated by Student #3 "Different students have different [learning] speed, in HyFlex learning, the faster student won't be slowed down, and the slower students can refer to the recordings". "… some students actually learn better by themselves at home, so basically we can choose the best learning method for us" (Student #2). This is in line with previous studies which indicated that the multiple learning modes of the HyFlex learning model could cater to diverse learning needs and paces among students [6], [8]-[11], [14] as well as enable them to achieve better academic achievement [12]. In other words, HyFlex learning allows instructors to ensure that slower learners are not left behind without sabotaging the progress of the fast learners. Such flexibility and adaptability are vital in developing countries where significant disparities in educational background and access to resources exist.

2) Mandatory learning evidence kept online students accountable for learning

Another factor which contributed to the similarity in academic achievement suggested by the participants was the enforcement of "… learning evidence, because you [the instructor] treated it as our attendance for the online students, which pushes us to make progress in learning" (Student #5). Student #4 shared the same sentiments by saying: "Ya, and because you [the instructor] set a deadline, so that pushed us more to go through the recordings, and I think that helped us in making sure we were not left behind on our progress of doing the project". This result is consistent with the findings from previous studies which concluded that students' attendance plays an important role in influencing their academic achievement [10], [11]. This approach addresses the common concern in self-directed learning as it may be a new concept for many students in developing nations. This strategy allows remote students to remain engaged with the course materials, especially among students who juggle multiple responsibilities. Thus, bridging the gap between P and online learners.

3) Instructor's feedback enhanced students' understanding

Furthermore, the students also signified that the instructor's feedback was also key to students' academic success, as mentioned by Student #4, "Oh your [the instructor's] feedback helps a lot too, and we are able to receive feedback from you no matter which learning mode we choose and that increases our understanding". This result agrees with previous studies which postulated no significant difference in academic achievement among the students because they were able to engage with the instructor and the learning activities regardless of the learning modes [10], [11], [14].

Collectively, the aforementioned themes justify the similarity in academic results among the students in Table II. Despite attending via different learning modes, the students were able to access the same quality of instruction and materials, as well as receive feedback from the instructor. The asynchronous option allowed students to engage with the content at their own pace, which can be beneficial for those who need more time to process information as well as those who have scheduling conflicts. As the instructor considered the learning evidence of online learners to be their attendance, students were more likely to complete the online learning activities. These enhanced students' understanding and engagement.

4) Students' sense of responsibility determines academic achievement

However, a few students also mentioned that their academic achievement "… depends on the students themselves, they need to know their responsibilities and priorities as a student" (Student #6). Student #3 further added that learners "… should adjust if a particular learning mode doesn't work for him or her, like me, I enjoyed online asynchronous at first, but then I switched to physical

once I caught myself slacking". This is in line with the findings by Binnewies and Wang [13] which concluded that students' self-management skills could affect their learning outcomes. This suggests that when implementing HyFlex learning, the instructors can consider offering resources or incorporating lessons on self-management to foster a sense of responsibility. It is also vital for instructors to communicate the expectations for each learning mode. Additionally, instructors could provide support at the beginning of a HyFlex course, and gradually reduce direct support as the course progresses.

5) Physical presence of peers and instructor enhances students' learning interests

A P learning environment is more conducive for the students when compared with online modes as they can have direct communication with their peers and instructor. When the participants were asked to compare their learning experiences between the three learning modes, most of them shared that they liked the P mode better because they "… were able to have direct face-to-face interaction with peers and instructor" (Student #1). Student #8 shared the same sentiment with Student #1, saying: "Ya, if I have anything that I am not sure about, I can just ask my friends or lecturer and get immediate feedback…".

The P presence of peers also created a better sense of community as compared to other learning modes, which contributed to a more enjoyable learning experience, and enabled the students to stay focused on the instruction. This was reflected by the remarks made by Student #7, "When we are learning together with our friends, the vibe [vibration] is better, it is more enjoyable, like sometimes we compete with each other, when we see others can do it, we would want to achieve it too, so it becomes easier to focus". Also, the P presence of the instructor was more effective in keeping the students accountable in their learning, as shared by Student #5, "… because you [the instructor] are physically there in front of us, we would be more cautious and remind ourselves more to stay focused".

As this could also be achieved in an OS learning mode, the researcher prompted the participants about the nuances between P and OS learning modes. "Ya, when learning through Zoom, we can also ask you [the instructor] if we have any questions but it is more intimidating to ask questions in Zoom because I would feel like disturbing the class and everyone would hear me. We always ask our friends first, like in class we could just talk or whisper to the friend beside us. But it's harder to interact with my friends during online sessions, we have to either chat through texting or wait for you [the instructor] to open breakout rooms, so it becomes harder and slower", says Student #3.

It is also harder for the instructor to gauge OS students' progress, "Also, when learning through Zoom, students can easily switch off their camera and put their laptop at the side and do other things, even though you [the instructor] call our names from time to time and always encouraged us to switch on our webcam, it is just harder as compared to P classes because when students are in the classroom, they don't have any excuse" says Student #6. These findings resonate with previous studies which found potential disparities in learning interests among online and face-to-face students [4], [7], [8], [14]-[16]. The findings highlight the importance of considering the cultural, technological, and pedagogical aspects of HyFlex lab sessions. This links to the following themes.

6) Feelings of disconnection, increased distractions, and tendencies to procrastinate in OA learning

When learning via OA mode, the students' predicaments in staying focused on learning were worsened, "… if it's online asynchronous, no need to say much, it's the hardest among all learning modes to stay focused" says Student #2. This is largely due to the feelings of disconnection between them and their counterparts and instructors, which caused them to be more prone to distractions when watching the recorded sessions and procrastination in completing the learning tasks. This was apparent in a few students' remarks, "… because it's only you yourself when learning online asynchronously, there was no interaction at all, although I see your [instructor's] and their [peers'] faces on the recording, but I know they are not really there because it's not synchronous right. So I do not feel connected" (Student #8).

Student #7 also shared, "Ya, and because we can watch the recording at our own time, we would always feel like, never mind, just do it later, and later, we would feel like nahh, I can do it tomorrow, haha like keep pushing it to tomorrow". Student #1 added, "Also, when we are watching the video, just like what Student #7 said, we are alone right, so it's easier to get distracted by our phones, or something on our desk, in our room, our family members, or the sounds from outside the house. Basically, our attention is not long. And because of that, we would skip parts of the video or increase the playback speed". Student #6 also commented, "or sometimes because I lost focus, I would need to keep rewinding the recording, which makes the learning process longer". This corresponds with the findings of previous studies which postulated that students' self-management skills could affect their online learning experiences [13]. This result also justifies the significant difference in learning interest between P and OA learning modes shown in Table III. This highlights the pertinence of direct social interaction, self-directed learning skills and learning environment in OA learning. Hence, the sense of community in OA settings should be enhanced through pedagogical and technological approaches. Practitioners could also consider utilising OA learning only for supplementary resource purposes such as revision and critical scenarios whereby students are unable to participate synchronously. Also, educators should monitor students' progress through formative assessments, especially among OA students. In cases where OA students cannot fulfil the expected progress benchmark, they should be encouraged or required to transition to P or OS learning modes to receive more direct guidance.

7) Familiarity breeds interest in learning

The undergraduate students were more interested in learning in a P learning mode because it has been the standard learning method since their childhood, "… we have been learning through physical class since kindergarten, we are used to this teaching method" says Student #8. The reason why the students' learning interest in OS learning mode was not significantly lower than the P students was because they gained experience in this learning method during the COVID-19 pandemic, as shared by Student #7, "For online synchronous, we sort of learnt how to do it during the pandemic, that's why we are okay with it. But for online asynchronous, it is still something new for us". "Ya" agreed Student #8 and #1. This justifies the higher student learning interests in P learning mode

shown in Table III. This finding is consistent with those from previous studies which showed that students were more interested in the P learning mode during the initial experience with HyFlex learning as it was a learning mode that they were more accustomed to [10], [11], [16]. The studies also found that from the second semester onwards, the students became more interested in the online options of the HyFlex learning model. This also indicates that although students might be relatively less interested in learning via OA mode, this learning mode has the potential to retain students' learning interest once learners are familiarized with the learning mode and are equipped with OA learning skills. Hence, HyFlex students should be provided with training in self-directed learning and time management skills. Educators also could limit the proportion of OA learning options for students during the initial stages of the HyFlex instruction while students are developing OA learning skills. As students demonstrate proficiency in managing OA learning, educators can progressively expand the OA learning slots to the students. This approach ensures that students are adequately prepared for the HyFlex learning model.

8) Flexibility in learning promotes interest in learning

Based on the students' sharing, the flexibility for online options within HyFlex learning made learning more accessible for learners who needed to travel to campus during peak hours or had tight schedules, which increased their learning interest. Student #2 shared "… I actually enjoyed online synchronous learning a lot because it is convenient for me. Like me, if there is no online option, I would need to go through traffic jam because our session is in the morning. It's like, we have options, when we can't or don't want to attend physically, we can learn via online, and sometimes some of us have other commitments that clash or are very tight to the lab sessions' timing". The option to attend classes online eliminates the need for commuting and allows learners to manage their own time more effectively.

Student #4 reinforced this comment by saying "Ya, there were a few times when the class before your [the instructor] session was cancelled, so we can just join via online and don't have to come to campus just for this one session". Student #5 further commented, "There were also times when I fell sick and couldn't even join Zoom session, but with the recording, I was still able to learn, so I was really happy about that". This explains the high overall mean scores of learning interest in Table II. The ability to choose between attending sessions physically or online based on students' circumstances enables them to juggle various responsibilities and switch to online sessions when unforeseen changes occur, making education more accessible and enjoyable. This reflects the results of previous studies which found that students cherished the flexibility to choose their preferred learning modes in a HyFlex learning environment [6], [9].

9) Technical difficulties affect learning motivation

Weak internet connection and technical issues affected students' online learning experience and their understanding of the instruction during the session, which negatively impacted their learning interests. "…when the wifi is unstable, we would miss out on important information. And like what Student #3 mentioned, we would feel like we are disturbing the class if we ask you [the instructor] to repeat. So, it becomes harder to follow the session and less fun to learn" (Student #6). In some OA student cases, they could not watch the recordings directly on the cloud. They would need to download the recording, which is a large file, and the waiting time further diminished their motivation to learn via the recorded session. This was indicated in Student #4's sharing, "… I need to download the recording because I couldn't watch the video, so it's like I am ready to study but now I need to wait for the download, so I'll play my phone while waiting, then when the download is complete, I lose that momentum to study". This is in line with the conclusion drawn by previous works which suggested that technological difficulties could affect students' HyFlex learning experiences [1], [14]. This illustrates why the online students reported lower learning interests as compared to the in-person students, as shown in Table III.

V. Conclusion

The comparable academic achievement among P, OS, and OA modes implies that equity in learning outcomes could be achieved in a HyFlex lab session among Malaysian undergraduate students despite the different modes of learning. This reinforces the flexibility of HyFlex learning in accommodating diverse student needs and circumstances without compromising academic results. The significant difference in learning interest between P and OA learning modes signifies that there are areas for consideration in uplifting students' motivation when learning via OA mode.

The findings offer opportunities for developing countries to expand access to higher education, especially for rural students, working adults, and students with disabilities or health issues who may not be able to relocate to the campus. For developing countries with limited resources, HyFlex learning could potentially be a cost-effective way to increase educational capacity as it could reduce the need for physical infrastructure expansion and potentially lower the cost of education for students. Also, HyFlex learning prepares students for a digitally driven workforce and enhances digital literacy across the population, which supports the Industry 4.0 initiatives in developing countries such as Malaysia.

However, the findings also imply several challenges for developing countries in implementing HyFlex learning. Efforts are needed from the public and private sectors as well as the NGOs. The disparity in learning interest between OA and P modes could be reduced by redesigning curricula to be more suitable for OA delivery, retraining educators in OA learning facilitation, establishing student support systems for online students, as well as exploring innovative technologies such as virtual reality and gamification. However, these initiatives might be constrained by financial resources and time. The digital divide also needs to be addressed. Internet infrastructure and access to electronic devices ought to be improved, especially in marginalized areas. Finally, the potential resistance from traditional faculty members could also be one of the hindrances. Policymakers or higher education institutions could incentivize quality implementation of HyFlex instructions and establish guidelines for managing synchronous and asynchronous components in HyFlex learning.

The limitations of this study include the limited sample size, the findings of this study should only be generalized to populations of similar backgrounds to the participants of this study. Future research can include samples from other demographics to enhance the external validity of the research outcomes. The majority rule used in this study to segregate the learning mode groups of the

students could also be improved. Future studies could employ more distinctive methods in grouping students into different learning modes of HyFlex learning to enhance the validity of the findings on the difference in students' learning outcomes.

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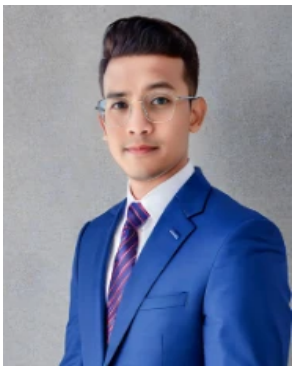

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