Research article

Academic integrity in the HyFlex learning environment

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ABSTRACT

This study analyzed how students' personality traits and course attendance preferences impact academic integrity in the HyFlex learning environment. 535 undergraduate students were given a choice among courses face-to-face (F2F), online, or a hybrid combination of both. The Big Five Inventory and the Academic Integrity Inventory were administered through online questionnaires to STEM students. The findings show that emotional stability and agreeableness positively relate to academic integrity irrespective of attendance mode. So do conscientiousness and agreeableness in the hybrid environment. Conversely, the primarily F2F attendance mode and the personality trait of extraversion are tied to markedly low levels of academic integrity. We conclude that unveiling students' personality traits associated with ethical behaviour would be beneficial when designing HyFlex courses in different learning environments, whether human (F2F), machine-made (online) or a combination of both (hybrid). This, in turn, contributes to better higher quality education and enhances academic integrity.

1. Introduction

In response to the pandemic, colleges and universities across the globe were forced to rapidly shift from traditional face-to-face (F2F) teaching to emergency remote teaching (ERT) education [1–3]. Moreover, teachers and students were the second-largest groups of digital technology users during the pandemic [4]. Notably, digital technology has changed higher education teaching and learning interaction and strategies [5], allowing technology-enhanced distance learning, blended learning, or combined on-site and distance learning, such as HyFlex [6,7].

This study is concerned with the HyFlex hybrid learning format that includes F2F and ERT instructional components [8], specifically how, for each class meeting, students are allowed to choose between physically attending the lecture in a classroom environment or remotely in a virtual setting [9]. HyFlex courses enable full flexibility of participation where students choose attendance mode: face-to-face, online synchronously, or mixed attendance. Furthermore, students might change their attendance mode throughout the semester [10].

HyFlex, similar to other hybrid learning programs, offers a good balance between work, family, and other obligations, allowing students to avoid costly commutes and course conflicts [11,12]. The HyFlex course design provides two modes of communication between the instructor and the F2F and remote learners: semi-directional (one-way) and bi-directional communication, where remote learners can communicate with F2F students and the instructor in real-time [13,14]. Because of this, the HyFlex learning environments

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also present notable logistical and pedagogical challenges.

Furthermore, the hybridisation of the learning environment is associated with breaking traditional scheduled boundaries between family time and study time and the need to monitor learning in multiple locations via diverse communication methods [15]. According to Raman et al. [16], HyFlex education during the COVID-19 pandemic differs from traditional HyFlex education during normal circumstances. More concretely, it differed from the traditional HyFlex model as it was implemented amid a pandemic when students had no choice. Consequently, most higher education institutions that adopted the pandemic version of "emergency HyFlex" did not have the infrastructure necessary to facilitate equitable learning experiences and outcomes across all learning modalities as in the traditional HyFlex format. On the one hand, such challenges include monitoring academic integrity [17]. On the other hand, it is widely known that technology affects an individual's ethical behaviour [18].

Non-traditional learning environments (e.g., hybrid and HyFlex) are highly vulnerable to academic integrity-related issues, such as buying and selling assignments and exploiting bugs in virtual tests or submission systems [19]. Moreover, the different HyFlex attendance modes, namely HyFlex primarily F2F, HyFlex primarily online, and hybrid (a combination of either F2F or online), present distinct pedagogical challenges and markedly different learning outcomes [20].

However, research into HyFlex is still in its infancy [21]. Therefore, little is known about the correlates of unethical student behaviour across the different HyFlex attendance modes. Nonetheless, some evidence suggests that although HyFlex learning may be suitable for many, it is not necessarily the right fit for all [22].

Although many contributing factors to academic dishonesty have been cited in the literature, there is no consensus regarding its primary cause. Some studies have emphasised the role of situational or contextual factors, such as the academic discipline [23,24] and the learning environment [25,26] alone or combined. For example, research has found that HyFlex and off-campus courses might be particularly challenging regarding academic integrity for students in science, technology, engineering, and mathematics (STEM) disciplines [23]. Specifically, HyFlex instruction necessitates sound technical and campus support, making it less suitable for subjects that require extensive laboratory work [27]. This notion is strengthened by the sharp increase in file-sharing websites among STEM students during the pandemic [23]. Other studies have focused on individual characteristics, such as students' demographic and personality traits [28,29]. An example of such research is a study by Ref. [30], showing that male students enrolled in hybrid courses are more likely to act dishonestly than female students.

In addition, another line of research has focused on the interaction between situational and individual variables as predictors of academic dishonesty [31,32]. One example is the [33] study, which examined academic dishonesty in F2F as opposed to distance learning. They found that extraversion's personality trait correlates with a greater disposition to cheat in the F2F mode but not in the online learning environment.

We rely on deterrence and neutralisation theories to clarify academic misconduct behaviour [34,35]. Deterrence theory stresses the potential causes of academic dishonesty and offers solutions to reduce this behaviour. It posits that students are more likely to engage in academic misconduct when they believe that the benefits of their dishonest actions outweigh the risks of being caught [36]. For example, regarding the relationship between academic dishonesty and the learning environment, remote instruction is associated with a sense of anonymity, leading to an increased perception of opportunities for cheating [28]. Neutralisation is another theory used to understand dishonest behaviour and is widely considered when investigating student misconduct [37]. According to this theory, students may justify their dishonest behaviour by claiming they have been victims of circumstances. The denial of responsibility protects students from being held accountable or feeling guilty for their actions [35,38]. In the context of remote instruction, students, for example, may feel compelled to cheat if they feel ill-prepared or uncertain about the content being tested or how it will be administered [39]. These theories are supplemented by a different but complementary framework related to the role of personality traits in academic dishonesty. Particularly, there is a growing interest in the role of personality in explaining unethical academic behaviour, with considerable scientific attention drawn to the Big Five personality traits theory [40,41]. The Big Five personality traits theory holds that students behave dishonestly depending on their key traits or predominant personality type [40]. Based on the deterrence and neutralisation theory and the Big Five personality traits construct, this pioneering study seeks to understand the extent to which students' academic integrity can be influenced by the HyFlex mode of attendance and which type of students are best fitted in each mode.

In summary, the pandemic catalysed many adverse pedagogical changes, mainly the growth in academically dishonest behaviours. Furthermore, it has become clear that HyFlex and hybrid pedagogy will continue beyond the COVID-19 era [42,43]. It has been shown that unethical academic behaviour could lead to undeveloped credentials or skills, thus resulting in professional incompetence, which would severely affect the validity of learning and the broader application of learning in future professional life [26,44,45]. Hence, studying the prevalence of academic dishonesty in the HyFlex learning environment will become ever more important, as will developing strategies to prevent it. Furthermore, identifying relationships between personality traits and academic integrity across the different HyFlex modalities, or attendance modes, might offer instructors a novel way to evaluate and understand the effects of computer interaction on their students' ethical behaviour.

Thus, the current research aims to determine the impact of the HyFlex learning environment on academic integrity. To this end, this study categorised STEM students' attendance choices as primarily online, primarily F2F, or hybrid and examined its correlates with academic integrity and personality traits. Furthermore, to better understand academic integrity in HyFlex, we also examined whether dispositional demographic factors, personality traits, and the primary mode of attendance have differential predictive power for academic integrity.

1.1. The HyFlex model in higher education

Higher education teaching and learning practices include various pedagogical methods and strategies, e.g., electronic instruction and the inclusion of management systems or educational management platforms [46]. According to Beatty [8], the Hybrid-Flexible (HyFlex) model is a student-centred approach to learning in which students can decide whether to attend each lecture on-campus or remotely in virtual classrooms. This teaching modality or learning environment is based on four main principles: student choice (in the modality), equivalency (in student learning outcomes regardless of the modality), reusability (of educational content and learning activities for the different modalities), and accessibility (to the technology and skills required to engage in all modes). Major benefits associated with HyFlex have scheduled/commuter flexibility, reduced course time conflicts, convenience, and the combination of virtual and campus-based interactions between students and instructor and among students [11,12,47].

Most existing literature on HyFlex is exploratory or qualitative and only focuses on students' experiences, organisational implementation or technological design. Empirical studies have only started to develop, and more research is needed into different pedagogical scenarios and their impact on student outcomes [21], including ethical behaviour. Thus, this pioneering research is based on previous research on the interaction between academic misconduct in previous learning environments [26,32,48,49].

1.2. Academic integrity

Quality education and academic integrity are related [50], constituting all learning processes. Understanding this has contributed to expanding scholarly knowledge on academic integrity and preventing academic dishonesty [51,52]. Whereas academic integrity refers to trustful, respectful, fair, and responsible behaviours [53], academic dishonesty refers to offences which include: Cheating, plagiarism, fabrication, and facilitation [54].

Recent studies have referred to academic dishonesty as a simultaneously moral and practical issue [55], directly affecting subsequent professional life [50]. Some scholars have pointed out that developments in instructional technology, along with a rapid increase in the offer of online courses, are among the major causes of academic dishonesty [56]. Due to these, plagiarism is turning into a frequent phenomenon.

1.2.1. Academic integrity and the HyFlex learning environment

Each institution or program ensures the quality of its higher education and its educational standards primarily through the quality assurance process [57]. Occasionally, though, these academic standards are violated due to academic misconduct. The problem of academic dishonesty is not confined to traditional learning environments (conventional instruction on campus) but is also prevalent in non-traditional classroom settings, such as the hybrid, blended, and HyFlex formats [19,30,58]. Although choosing the mode of attendance can be a positive and motivating force for students, it can also lead to faulty outcomes in some cases [59], including: Seeking out bugs and loopholes in submission systems and exploiting them, taking advantage of the instructor, or engaging in contract cheating [19,60]. Additionally, although no field of study is immune to the practice of academic dishonesty, students' dishonesty is often conceived as a problem in STEM disciplines [61].

Nevertheless, it is erroneous to assume that external influences (i.e., the learning environment and academic discipline) alone are responsible for the deterioration of academic integrity, as students' personal characteristics also play an important role [33]. A prior study examining cheating in a non-traditional computer science course found gender differences in the likelihood of engaging in academic dishonesty [30]. Evidence also suggests that certain personality traits might be counterproductive in highly scientifically structured courses [62].

1.2.2. Academic integrity and different HyFlex attendance modes

Different attendance modes, whether in HyFlex, hybrid, or blended settings, may attract different types of learners: those who value flexibility and autonomy and those who value structure and social interaction [63]. For example, it has been reported that students who chose hybrid or F2F HyFlex course attendance performed better on exams and course assignments than those who chose to attend HyFlex courses remotely [64]. Further, hybrid-based attendance is linked to a greater sense of class engagement compared to remote or F2F [21], whereas remote attendance is tied to higher levels of self-regulation [63].

The literature on academic dishonesty in HyFlex is still in its infancy [21]. Previous research on the mode of study (F2F or online) addressed gender, faculty, and student understanding of plagiarism [65]. It established that male distance education students were likely to read the Academic Misconduct Policy independently of faculty affiliation. Nonetheless, it did not address plagiarism issues *per-se.* Other research [66] examined course attendance and students' perception of satisfaction, convenience, engagement, and learning in blended and online courses. It demonstrated that students' satisfaction, convenience, and engagement while taking exams through online attendance mode is higher than those through "In-person" attendance mode. It also demonstrated an association between students' achievement (i.e., grades) and learning mode, with higher achievements in online exams compared to in-person.

Thus, to the best of our knowledge, limited research examines the relationship between the choice of HyFlex primary attendance mode and academic integrity. Despite that limitation, we hypothesised the following based on the literature mentioned above that demonstrates the choice of attendance mode has different impacts on performance. We posit:

H1. The level of academic integrity will differ between the three HyFlex attendance modes.

1.3. Personality traits

Personality refers to an individual's distinct cognitive, emotional, and behavioural patterns [67]. The five-factor model (FFM) of personality traits is the most influential and widely used personality theory [68]. The FFM [69] consists of five broad dimensions of personality: Emotional stability, extraversion, conscientiousness, openness to experience, and agreeableness. Evidence suggests that no one-size-fits-all solution fits every personality type in different learning environments [32,48,70]. For example, students with certain personality types may benefit from campus-based F2F learning because it provides a rich social environment and opportunities for non-mediated communication. Alternatively, students with different personality types may benefit more from a hybrid learning environment or thrive in remote learning, where communication is exclusively mediated through technology [71,72]. For example, although extroverted students enjoy more natural learning environments (e.g., F2F instruction or two-way virtual practitioner), they often perform poorly under these conditions. Conversely, emotionally stable students enjoy and excel in all learning environments [31].

1.3.1. Personality traits and academic integrity in HyFlex

Research examining the individual factors underlying students' ethical behaviour in traditional (F2F) and non-traditional (remote or hybrid) learning environments have demonstrated that students' personality traits have a significant impact, negative or positive, on their academic integrity [29,32].

Extraversion reflects an individual's propensity to be sociable, assertive, talkative, daring, excitement-seeking [40], and impulsive [73]. Furthermore, this trait is positively related to cheating and rule-breaking [29]. Interestingly, [74] explored the factors influencing deviant academic behaviour based on deterrence theory, concluding that impulsive individuals are more difficult to deter due to their poor responsivity to risks, including the costs of potential punishments. Hence, one could speculate that highly extroverted students might be less hesitant to engage in academic misconduct. Accordingly, we hypothesise:

H2a. The higher the levels of extraversion, the higher the students' academic dishonesty levels.

Emotional stability (reverse of neuroticism), which refers to the tendency to be calm and distressed, is negatively linked with academic dishonesty [75]. Further, those who rank low in emotional stability are often anxious and prefer highly structured learning environments and, therefore, may struggle with a hybrid learning format such as HyFlex [76]. Hence, it can be inferred that, unlike neurotic students, students with high emotional stability might be less predisposed to employ deviant means, such as cheating or plagiarising, to cope with anxiety and avoid failure. Therefore, we hypothesise:

H2b. The higher the levels of emotional stability, the higher the levels of students' academic integrity.

Agreeableness, which refers to the tendency to be trustworthy, sympathetic toward others, and cooperative, is inversely related to academically dishonest behaviour [29]. Notably, it has been suggested that agreeable students might be particularly fit for hybrid learning. Hence, we hypothesise:

H2c. The higher the levels of agreeableness, the higher the levels of students' academic integrity.

Conscientiousness is the propensity to be goal-directed, disciplined, and achievement-oriented. Research findings show that conscientiousness is inversely related to academic dishonesty [29]. Furthermore, conscientious students are highly likely to adjust their behaviour to conform to norms [77]. Therefore, they are perceived as less likely to use dishonest means to meet educational demands. Accordingly, we hypothesise:

H2d. The higher the levels of conscientiousness, the higher the levels of students' academic integrity.

Openness to experience describes a blend of intellectual curiosity, creativity, and novelty-seeking traits. Moreover, individuals high on openness to experience tend to see the academic institution as an opportunity to acquire knowledge and consider the academic demands challenge rather than a threat [40,45]. Thus, it can be expected that students who are high in the openness to experience trait are less inclined toward academically dishonest acts. Thus, we posit:

H2e. The higher the levels of openness to experience, the higher the levels of students' academic integrity.

1.3.2. Academic integrity, personality traits, and HyFlex mode of attendance

Aside from their importance as independent factors, personality constructs and situational factors such as the learning environment may interact to produce meaningful outcomes that exceed their individual effects [78]. In the context of academic integrity, there is evidence showing that situational and individual factors can combine to influence student perceptions and intent to engage in academically dishonest acts [26,79]. For example, on the one hand, students' choices of attendance mode are optimal for them [59]. On the other hand, students' personality and their relationship to academic dishonesty [26,80].

Still, HyFlex remains an unexplored research territory with only a few scientific research [10]. Nonetheless, based on the above and previous literature reviewed above (sections 1.2 and 1.3), we hypothesise:

H3. The level of academic integrity will differ between students with different personalities depending on their primary mode of attendance.

1.4. The present research

According to Ref. [16], the COVID-19 HyFlex model is distinctively different from the traditional HyFlex model because it was

forced on students under stressful, pandemic-related circumstances and lacks sufficient pedagogical infrastructure. Implementing the COVID-19 HyFlex model might have brought unprecedented challenges for students and faculty. Furthermore, students' attendance choices influence their outcomes [59]. Therefore, any difference in learning outcomes between F2F, hybrid, and remote modes is potentially biased due to the student's personal characteristics [81]. Based on deterrence and neutralisation theories, we investigate how the HyFlex COVID-19 learning environment is likely to amplify any effect of personality on academic dishonesty. This is vital for the validity and success of HyFlex programs. Therefore, this study examines academic integrity (and its offences, academic dishonesty) in the different HyFlex attendance modes (primarily F2F, primarily online, and hybrid) among STEM students and their dispositional characteristics (demographic factors and personality traits).

2. Materials and methods

2.1. Participants

The research sample consisted of 535 STEM students at a public university in Israel (167 students from the disciplines of life and biotech; 213 students from the disciplines of math, physics, and chemistry; 121 students from the discipline of engineering; and 34 students from the discipline of computer science). Most students were single (92%), and the remaining were married (8%). More than half were women (56%), and the remaining were men (44%). The students' ages ranged from 18 to 39, with a mean age of 22.77 (SD = 3.16). Their course grades ranged from 43 to 100, with a mean course grade of 86.88 (SD = 11.36).

2.2. Measures

Personality traits were examined using the ten-item personality inventory (TIPI) - a brief version of the Big Five Factor [82]. The TIPI consists of 10 items, with two assessing each of the five personality facets. One item is positively keyed for every facet, and the other item is negatively keyed. Items are rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Internal consistency reliability was questionable (Cronbach's alpha = 0.64). They were translated into Hebrew by Peled et al. (2019). For this instrument's full reliability, see Gosling et al. (2003). Additionally, today, the five-factor model, or FFM, is the most widely used model of personality structure (Sleep et al., 2021).

Academic Integrity was examined using the Academic Integrity Inventory. This survey instrument included questions about the likelihood of considering misconduct [79] based on eight items with acceptable internal consistency reliability (Cronbach's alpha = 0.70). Translated into Hebrew by Ref. [32]. An example of a question is: "How likely are you to consider turning in work done by someone else as your own?"

2.3. Procedure

After University of Bar-Ilan Ethical review board approval, online questionnaires were administered to 623 STEM students at a public university in Israel at the end of the semester of 2021. The questionnaire took approximately 7 min to complete and had a dropout rate of 14%. The final sample consisted of 535 students. Students choose, for any given class, their preferred modality. For this study, we distinguished three HyFlex modes of attendance: primarily F2F, primarily online, or a hybrid of the two [64]. In the primarily F2F setting, the instructor and students share the same physical space. In the primarily online setting, students attend the lecture virtually from a distance via web conferencing software (Zoom or Google Meet). The mode of participation in this study included fully bi-directional interactions, where students could mutually communicate with their instructor in the classroom irrespective of their attendance mode. Implementation of the full HyFlex version of course delivery included a classroom computer, SmartBoard, two large TV screens (86 inches), and high-quality cameras optimised for live broadcasting.

2.4. Data analysis

Data were analyzed via independent sample *t*-test for H1, Pearson correlation for H2, one-way and two-way ANOVA for H3, and multiple regression analysis using SPSS software version 27.

Table 1
Academic integrity difference by STEM department.

Stem Department	n	Range	Mean	Std.	F
Life And Biotech	167	1.88–5.00	3.57	0.58	1.785
Math, Physics, And Chemistry	213	1.38–5.00	3.51	0.63	
Engineering	121	1.88–5.00	3.66	0.67	
Computer Science	34	2.63–4.63	3.67	0.48	
Total	535	1.38–5.00	3.57	0.62	

3. Results

First, we examined whether academic integrity levels differ by STEM discipline to distinguish the effects of situational/contextual factors from that of individual ones. The results did not indicate any significant difference in the level of academic integrity between the STEM disciplines, with a medium level (Mean = 3.57 is equivalent to a score of 71 on a scale of 1–100) of academic integrity among all STEM students. See Table 1.

Our next step was determining the impact of the primary HyFlex attendance mode on students' academic integrity. As shown in Table 2, students who preferred to attend lectures primarily F2F had lower levels of academic integrity (M = 3.47) compared to those who preferred a hybrid-based attendance (M = 3.59) significantly ($t_{(406)} = 5.06$, $P < 0.001$) and a primarily online attendance mode (M = 3.77) significantly ($t_{(374)} = 3.34$, $p < 0.001$), thereby supporting H_1.

Subsequently, we examined the relationship between personality traits and academic integrity. The results are reported in Table 3. The personality trait of emotional stability has a weak positive significant correlation ($r = 0.12$, $P < 0.01$) with the level of academic integrity, irrespective of the HyFlex attendance mode, which means that the higher the level of student's emotional stability, the higher the level of academic integrity, supporting H_{2b}. The personality trait agreeableness has a weak positive significant correlation ($r = 0.25$, $P < 0.001$) to the level of academic integrity, irrespective of the HyFlex attendance mode. That is, the higher the level of student's agreeableness, the higher the level of academic integrity, supporting H_{2c}.

The relationship between personality traits and academic integrity was further examined in the HyFlex attendance modes. In the primarily F2F attendance mode, agreeableness ($r = 0.29$, $P < 0.001$) and emotional stability ($r = 0.14$, $P < 0.05$) have a significantly weak positive correlation with the level of academic integrity. In other words, the higher the level of students' emotional stability and agreeableness in the primarily F2F attendance mode, the higher the level of academic integrity (Table 3). In the hybrid attendance mode, the personality trait agreeableness ($r = 0.35$, $P < 0.001$), has a significant moderate positive correlation with the level of academic integrity. Additionally, the personality trait conscientiousness ($r = 0.25$, $P < 0.001$) and emotional stability ($r = 0.21$, $P < 0.05$) has a significant weak positive correlation with the level of academic integrity. This means that the higher the level of a student's agreeableness and conscientiousness in hybrid classes, the higher the level of academic integrity (Table 3), thereby partially supporting H_{2d}.

In addition to analysing student personality traits and the primary HyFlex attendance mode separately, we also examined whether and how these two factors combined influence academic integrity. As shown in Table 3, there was a significant interaction effect of extraversion and attendance mode on the level of academic integrity ($F_{(16,508)} = 2.34$, $p < 0.01$), thereby partially supporting H_{2a}.

Post-hoc analysis revealed that the combination of extraversion trait and primarily F2F attendance created particularly low academic integrity levels compared to the primarily online ($t_{(8,508)} = 4.52$, $p < 0.001$) and hybrid ($t_{(8,508)} = 4.68$, $p < 0.001$) attendance modes.

Thus, based on these findings, we infer that the level of academic integrity varies considerably between students with different personalities depending on their primary mode of attendance, thus supporting H_3.

Next, a multiple linear regression was performed to determine significant predictor variables for student academic integrity. As shown in Table 4, the variation of the regression is 12%. The regression analysis indicated (at the final step) that the personality trait Agreeableness ($\beta = 0.25$, $p < 0.001$) is a major predictor of students' academic integrity in HyFlex courses. Similarly, the primarily online attendance mode ($\beta = 0.21$, $p < 0.001$) and the hybrid attendance mode ($\beta = 0.12$, $p < 0.001$) are also significant predictors of students' academic integrity. Last, the socio-demographic variables gender ($\beta = 0.11$, $p < 0.05$) and marital status ($\beta = -0.09$, $p < 0.05$) were also found to be significant in the regression analysis. That is, female students have a higher level of academic integrity than male students in the HyFlex environments, irrespective of the primary mode of attendance. See Table 4.

4. Discussion and implications

COVID-19 has abruptly forced higher education systems to implement HyFlex learning. The literature on its impacts on higher education has been well-documented [83,84], but these previous studies did not inquire about the pandemic's impact on STEM students' ethical behaviour according to their attendance modes. Thus, in the present study, we examined whether STEM students' levels of academic integrity differ in F2F and HyFlex attendance modes. Additionally, we investigated the relationship among dispositional characteristics (socio-demographic factors and personality traits), mode of attendance choice and academic ethical behaviour. The following theories underpin this study: the neutralisation and deterrence theory.

As a first step, we examined whether academic integrity levels differed by STEM discipline. The results show no difference in academic integrity levels among STEM disciplines, with all STEM students having a medium level of academic integrity. Consequently, it can be concluded that academic discipline does not directly impact students' academic integrity. Instead, the HyFlex primary mode

Table 2
Academic integrity difference by attendance mode.

Attendance mode		t	F
Primarily F2F Vs	Primarily online	5.06***	14.11***
Primarily F2F Vs	Hybrid	3.34***	
Primarily online Vs	Hybrid	1.21	

Note. ***p < 0.001; n = 535.

Table 3
Academic integrity correlation with personality traits by attendance mode.

	Personality traits				
Attendance mode	Extraversion	Agreeableness	Conscientiousness	Emotional Stability	Openness to Experiences
Primarily F2F (n = 249)	0.12	0.29***	0.04	0.14*	0.08
Hybrid (n = 127)	−0.09	0.35***	0.25***	0.21*	0.12
Primarily online (n = 159)	0.06	0.12	0.00	0.01	0.14
Total (n = 535)	0.00	0.25***	0.07	0.12**	0.07
F	2.34**	1.53	1.28	0.85	1.76
η^2	0.07	0.03	0.03	0.03	0.04

Note. *p < 0.05; **p < 0.01; ***p < 0.001.

Table 4
Multiple regression analysis of personality traits and socio-demographic variables as predictors of academic integrity.

	Predictors	β	t	F	R^2	ΔR^2
Step I	Gender (0 = Female, 1 = Male)	0.09	1.93	3.73**	0.03	==
	Age	−0.11	−2.49			
	Average grade	0.00	−0.08			
	Marital status (Single = 1, Married = 0)	0.00	−0.04			
	Travel time to university	0.12	2.84			
Step II	Gender (0 = Female, 1 = Male)	0.12	2.61	6.46***	0.09	0.08
	Age	−0.12	−2.83			
	Average grade	−0.02	−0.43			
	Marital status (Single = 1, Married = 0)	−0.01	−0.19			
	Travel time to university	0.14	3.24			
	Extraversion	0.04	0.84			
	Agreeableness	0.26	6.01			
	Conscientiousness	0.03	0.70			
	Emotional Stability	0.00	0.03			
	Openness to Experiences	0.04	0.90			
	Predictors	β	t	F	R^2	ΔR^2
Step III	Gender (0 = Female, 1 = Male)	0.11	2.46*	7.12***	0.12	0.03
	Marital status (Single = 1, Married = 0)	−0.09	−2.20*			
	Age	−0.03	−0.57			
	Average grade	−0.01	−0.12			
	Travel time to university	0.07	1.53			
	Extraversion	0.07	1.59			
	Agreeableness	0.25	5.82***			
	Conscientiousness	0.03	0.57			
	Emotional Stability	0.00	−0.01			
	Openness to Experiences	0.05	1.20			
	Hybrid	0.12	2.66**			
	Primarily online	0.21	4.23***			

Note. *p < 0.05; **p < 0.01; ***p < 0.001; n = 535.

of attendance is more important to academic integrity, particularly the primarily online and hybrid attendance modes. In the study, students who preferred to attend lectures primarily F2F had a lower level of academic integrity than those who preferred primarily online or hybrid modes of attendance. Our findings support hypothesis H1 and further strengthen previous evidence indicating that students tend to cheat more often in F2F than in online settings [32]. These results may be analyzed based on the deterrence theory [85]. The lower tendency to behave dishonestly by students who prefer the hybrid and primarily online modes of attendance may be related to the internal controls imposed in these learning settings.

Another interesting finding is that students' gender strongly influences the tendency to behave (dis)honestly, with female students having greater academic integrity than male students regardless of the primary HyFlex mode of attendance. This finding might be explained by neutralisation theory considering previous non-HyFlex research by Ref. [86], which showed that male students tend to justify their dishonest behaviour more readily than their female counterparts.

Additionally, the results showed that emotional stability and agreeableness were associated with a higher level of academic integrity in HyFlex courses, thus supporting our research hypotheses H_{2b} and H_{2c}. On the contrary, and supported by literature [29], no correlation was found between openness to experience (H_{2e}) and academic integrity. This may be due to the influence of the innovative HyFlex context and the general tendency of individuals high in the openness trait to appraise academic demands as challenges instead of threats [45,87] does not necessarily translate into greater academic integrity. In addition, we found that higher conscientiousness (H_{2d}) and agreeableness (H_{2c}) in hybrid classes are related to higher academic integrity. It may be that a hybrid environment is particularly beneficial to these personality traits since it offers both flexibility and opportunities for interpersonal interaction. This notion is reinforced by prior studies [76,78]. A peculiar finding was that the primarily F2F attendance mode and the personality trait of extraversion (H_{2a}) combined create particularly low academic integrity levels compared to the primarily online and hybrid modes.

This is supported by previous research literature [70].

The most interesting finding of this study is that every personality trait may interact differently with each HyFlex attendance mode, supporting hypothesis H$_3$. This is supported by literature [88], as human-computer interaction is mediated by user characteristics, like personality traits, and computer system designs, like HyFlex. In other words, research has established the influence of personality traits on human-computer interaction and its implementation as a personalisation tool [89].

Overall, in line with research [90], educational technology, like HyFlex, is a constantly evolving relationship between artificial intelligence and human interaction. The present research findings add to this research field thus: (a) findings demonstrate the value of incorporating a combination of theories to capture distinct patterns of academic integrity breaches; (b) understanding the interaction of personal characteristics affects academic integrity in digitalised versus non-digitalised learning environments allows instructors and educators to design better instructional methodologies and interactions thus enhancing and ensuring academic integrity and quality education.

4.1. Practical implications

This study has several important implications for practice. First, our findings reveal that situational and dispositional factors interact complexly to affect academic integrity, as demonstrated in previous literature [32,48,70]. Therefore, based on our findings, one may assume that academic integrity violations are more likely to occur in the HyFlex, primarily F2F attendance mode, compared to the hybrid and primarily online modes. Moreover, not all students benefit equally from HyFlex, as those who are more extroverted may have difficulties behaving honestly in HyFlex, primarily in F2F classes. Accordingly, educational interventions promoting academic integrity should target highly extroverted STEM students in HyFlex F2F settings.

5. Conclusion

The present study offered important insights into how HyFlex attendance mode and personality traits shape STEM students' academic integrity. Overall, results indicate that the HyFlex instructional model had no negative impact on student academic integrity. Moreover, students' preferences for HyFlex and primarily online attendance modes are predictive of academic integrity. While no significant differences between STEM disciplines in terms of academic integrity were observed, the results indicate that the academic integrity level of STEM students who attend HyFlex courses, especially those who primarily attend F2F, needs to be improved. Furthermore, HyFlex and other hybrid learning approaches are expected to continue beyond the COVID-19 era [42,43]. Thus, providing proper training to faculty and technical support teams is key to students and instructors benefiting from HyFlex STEM teaching; however, it is essential to note that some critical individual differences may affect students' academic integrity. Accordingly, it would be beneficial to consider personality characteristics associated with high levels of academic integrity when designing HyFlex STEM courses to provide students with an optimal learning environment.

5.1. Limitations and future research

There are some limitations to this study. First, our data is based on the instructors' and students' first HyFlex semester. The results may not fully reflect the students' learning curve effects or the instructors' adaptations to the new HyFlex technology. A second limitation is that the students participating in this study were forced into the HyFlex learning mode. Adjusting to HyFlex meant restructuring class time, extracurricular activities, and deadlines [8]. These rapid and sometimes undesirable changes may have hindered students' motivation to behave honestly. Future research could investigate whether student learning motivations in HyFlex courses correlate with their academic integrity level. Finally, the present study focused on academic integrity among STEM students. In future research, it would be interesting to investigate whether our results apply to social science students. Future research may also consider personality traits among different genders and their relation to academic integrity in HyFlex.

influence the work reported in this paper.

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