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Gender impact on STEM online learning- a correlational study of gender, personality traits and learning styles in relation to different online teaching modalities

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Abstract
STEM (science, technology, engineering and mathematics) education benefits both individuals and society. It supports individuals by increasing their critical-thinking skills, encouraging creativity, as well as providing a basis for new inventions. The underrepresentation of women in STEM is a complex issue with various causes and different approaches of addressing it, where most likely gender differences are caused by desires and choice rather than abilities and performance. This paper explores differences in online and traditional STEM learning based on gender. It examines in detail recently identified patterns of women's success, their access to STEM online courses, and their overall course experience during such courses. We analyzed results from a case study in which students were enrolled for one semester in two STEM online courses and completed questionnaires about their character traits and learning styles and how they relate to academic performance. The objective of our research is to analyze academic success during traditional classes and online classes, with focus on gender and identify how character traits and learning styles correlate with gender in online classes. The main outcome of our research is that female students, which study in the field of STEM in particular computer science, are trustworthy and autonomous students who can outperform their male counterparts during traditional courses, where during online courses male students still exceed slightly female students. The trait of Consciousness is a success

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predictor regardless of gender and learning environment, while the trait of Neuroticism has negative impact the traditional learning environment, Extraversion shows negative impact in online learning. Learning styles show gender differences, where female students prefer the style of read/write while male students favor kinesthetic.

Keywords Online education · STEM · Big five · Gender · Learning style

1 Introduction

In our daily social interactions, the usage of computers and the Internet has become a necessity. Education has certainly not been left out by the impact of digitalization [1]. However, the educational system was met with a need to rapidly shift to nearly full online teaching and learning, with imminent changes in educational systems made more apparent by the Covid-19 pandemic. A challenge for educational institutions worldwide, the Covid-19 pandemic required adaptive and appropriate guidance in designing and continuing the educational process, as a basic requirement to ensure young people's educational opportunities during and after the global pandemic [2]. The Covid-19 pandemic also put to the test online learning, which in turn resulted in the capacity building of faculty staff who had to learn and test new tools and systems of online learning [3]. Therefore, a possible shift in mind and perception is taking place, given that this experience has opened a new horizon of opportunities for online learning and remote teaching [4]. It will ultimately also enhance the opportunities for working from online and the chance for learners to access lifelong learning opportunities. Online education utilizes the Internet to create versatile and more educational options for students.

Firstly, the Internet was labelled as an autonomous and unbiased interaction platform. However, the desire for women to balance work and family responsibilities has seemingly limited female Internet presence [5]. Consequently, this has raised questions about equality in online education, particularly for women. In online learning, the goal is to seek and integrate a greater dimension of transparency and versatility with regard to entry, curricula or other systemic elements. Research for understanding gender differences is ongoing. The most critical issue is that the consequences of gender are isolated from the effects of cultural background or age influences [6] although the histories and position of men and women are significantly different, it is difficult to know if the samples are comparable. So, what is the position today? Are there gaps between the genders in online learning? This study focuses on these gender-based issues and utilizes case studies' explanations and analysis to address some of these concerns regarding students' academic interests, conceptions, and views of learning assistance in online environments [7].

In this paper we are looking at the dimension of how gender impacts the academic achievements in online classes and traditional classes, with a specific focus on learning styles and character traits. Participants of the case study conducted in relation to this were computer science engineering students, we discuss the impact of study variables with a focus on science, technology, engineering, and math (hereinafter referred to as "STEM") online courses, which, due to the use of applied science and mathematics, differ significantly from other disciplines in regard to online teaching. Especially the need for the assistance of professors in science laboratories has made STEM disciplines more challenging to teach online. Technological leaps over the past years have enabled computers to represent more complex structures and

objects. Furthermore, additional STEM disciplines were added, and curricula was modified to provide a workforce capable of meeting the ever-growing technological needs of society. Moreover, students of STEM disciplines gain invaluable practical skills through their respective training, such as: (i) problem-solving; (ii) quick information analysis (iii) decision making; as well as (iv) fostering their overall creativity and innovation. The evolution of STEM disciplines has mirrored changes in technology and society in the most recent history, and it will presumably continue to do so in the foreseeable future. The low participation rates of women in STEM courses remains a critical issue for social scientists and educationalists [10]. Even though international comparative research studies show that girls in numerous countries are now equal to or even superior to boys in mathematics and science [9] women continue to be under-represented in many STEM graduate [8] programs and professions. Studies on various participation rates have been conducted [11]. The studies point out that besides personal interests (e.g., self-confidence, expectations of competence in STEM), social and organizational structures (e.g., assumptions and attitudes of gender and the STEM roles available) are of significance to the weak participation of women in science. Measures undertaken to remedy the situation should therefore focus on both individual and environmental causal bundles as well as their interplay. Moreover, such interventions need to start early, as gender differences in individual factors become more significant with age. For example, girls' interest in STEM courses decreases more rapidly than that of boys as they progress through school [12].

The present study contributes to the existing body of knowledge by investigating the role of personality traits and learning styles on the students' impressions of online learning experience from a gender-based perspective.

Character traits are defined as coherent patterns of ideas, emotions, motives, and behaviors that an individual displays across circumstances [13]. Character traits in our case have been explained by using the model generated by Costa and McCrae [3] the so called "Big Five", which consists of a range of five different traits: *Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism.* Learning styles are another dimension of how a person learns and adapts to his or her educational environment [14]. One of the commonly used models of identifying learning styles is the model that Neil Fleming created in 1987. The model identifies four primary types of learning styles: *visual, auditory, read/write, and kinesthetics*, the initials of which are used to name the so called "VARK model [20].

This paper begins by discussing the significance of online learning and assessing the gender gap in this environment. Then it reviews previous research on how personality, learning styles, and gender are related to students' academic success, in online courses versus traditional learning (Section 2). Then it describes the case study's methodology, including how participants were chosen, divided into groups for courses of varying difficulty, and materials delivered (Section 3). Section 4 displays the analyses performed on the given variables to gain insight into which variables have positive or negative impacts on academic results, as well as the various roles such variables play in online courses versus traditional learning. Finally, in Sections 5 and 6, discussions and conclusions are outlined by demonstrating how different variables impact the results of online courses and traditional classes. The analyses show that: character traits influence test results (especially the conscientiousness trait, which has a positive impact regardless of gender); (ii) learning styles are more gender related; (iii) female students outperform their male counterparts in face to face classes where male students perform better in online classes.

2 Related work

2.1 General overview

Although the level of women's educational achievement has dramatically improved in the last few decades [15], women remain substantially underrepresented in STEM college programs and professions. Card and Payne [10] indicate that the gender differential probabilities of graduating with a STEM degree in the USA and Canada is the probable cause for the approximately 20% wage disparity between younger college-educated men and women, suggesting that the gender gap in STEM courses is essential to explain the gender gap in income [16]. To create a beneficial effect on students' career choices, it is crucial to enhance their STEM engagement at a young age. The cognitive-motivational system in schooling currently is focused on collectively formed and fortified views and opinions. Engagement in STEM enhances key factors of learning such as cognition (beliefs, objectives, attributions, values), actions (task persistence, effort), emotions (including good and negative affects) and general interest. Additionally, students who encounter all three key motivators — i.e., desire, capacity, and engagement — are more likely to bring full effort into STEM learning and ultimately affect academic results, including success and attendance [17].

The study of gender and education involves gender gaps in educational outcomes such as success, achievement and experience. This topic goes beyond the study of the effects of gender on education and the way these disparities have an effect on the job market, on family training and on health outcome [18]. Early studies into gender and education centered on whether differences were related to biological differences in educational performance among both males and females. Over time, studies have found that biological gender variations tend to be fewer than gender difference [19]. Primary school students' study [21] has explored how relationships between friends, teachers and families lead to gender disparities. Higher education research explores sexual separation through large differences in sex and gender in choices to attend or to complete universi [22]. Research has recently moved to explore the reasons and effects of reversing the gender gap in schooling. In most countries around the world, women are now overriding men in general university attendance and completion [23] However, there are also major gaps between the genders in the area of research and return to college qualifications. Taking into consideration the above, this study reaffirms the general understanding that biological disparities play a comparatively low role in schooling performance, whereas other influences such as socialisation and differences in aspirations of girls and boys play a greater role [24].

Knowing how stereotypes influence motivation can help mitigate one of the major problems of the contemporary STEM education system. The underrepresentation of women in STEM fields is troubling because it harms women and inhibits potential science and technical advances [25, 39]. An underrepresentation is evident at an early age. Multiple reasons and approaches for solving the problem of women's underrepresentation in STEM are needed [26]. New research indicates that gender gaps in attitudes and choices rather than skill and success are the most plausible reasons for this underrepresentation [27]. While there are no credible gender gaps in math capacity, girls are almost twice as likely as boys to have poor spatial abilities by the time they leave elementary school [28]. Girls in high school have good skillsets in different academic areas, which equip them for a broader variety of professions than boys [29]. Consequently, the continuing discussion is often focused on the topic of gender inequalities in priorities and expectations [30]. Prior findings suggest that females are confident about

online learning, as they are becoming increasingly more competent and autonomous learners in online research. In a self-regulated online learning community in Turkey for instance, there were no gaps in programming achievement due to gender differences [31]. In online STEM courses offered by an urban community college in the United States, females and males were seen to fare comparable in terms of progress rate [32]. It was also observed that female students performed higher than males in online courses offered by community and technical colleges in Washington State. Subsequently, it can be assumed that once females enrol in STEM courses, they would be as likely to complete them as their male counterparts Author [33]. In general, engagement in online STEM courses is to be perceived as very individualistic, hence why gender-based generalizations and assessments are indeed a complicated undertaking [34]. Little-Wiles' (Little, 2014) work is consistent with Beer, Clark, and Jones' [33] work in showing that there is lack of gender differences in course grades where male students slightly perform better. Furthermore, Little-Wiles [35] study is also consistent with Morante, [36], which results show that the more an individual is active in online environments, the higher academic achievement is granted [37].

2.2 Big five framework of personality traits and gender

The Big Five Framework of Personality Characteristics [38] has established itself as a sophisticated and coherent model for explaining the relation between personality and different academic behaviors. The Big Five Frame identifies in general five dimensions of personality traits, the characteristic of which are summarized below:

- ***Consciousness*** is illustrated by being disciplined, organized, and achievement oriented;
- ***Neuroticism*** related to the way of mental stability, control impulse, and anxiety;
- ***Extraversion*** is expressed through a higher degree of sociability, assertiveness, and talkativeness;
- ***Openness*** is reflected in a strong intellectual curiosity and a preference for novelty and variety; and
- ***Agreeableness*** is related to being friendly, cooperative, and compassionate towards others.

It should be noted that the capacity of personality traits to explain phenomena is anticipated to improve in settings where contextual clues do not restrict individual behaviors. This concept is especially applicable in online situations where the discretion of learners over learning behaviors is enhanced [45]. Online learners are less restricted to meet social expectations compared to face-to-face courses. They have more liberty about the nature and frequency of social interactions [40]. It is also noteworthy that, apart from all the study results, Consciousness is the personality trait that is the most linked to positive learning results for both male and female students [37] The relationship between Consciousness and online course impressions was studied by measuring of commitment factors, career value, general assessment, anxiety, and preference of online courses. A significant link was identified to exist between this specific personality trait and general impressions on the online course [41]. Particularly in STEM courses the trait of Consciousness is the personality trait with the most impact on students' academic achievement [42]. Research on different character traits studied from a gender focused perspective shows that women are generally perceived to be more nurturing and score higher in the trait of Agreeableness and are more Neuroticism, in contrast to males which generally score higher on the traits of Openness and Extraversion. However, as already pointed

out above, personality traits are very individual and general categorization of male and female students based on them is not fully possible at the moment, and therefore should be studied and researched further. A key goal of this paper is to add to the stream of literature on personality traits and their correlation with gender and academic achievements [42, 43].

2.3 VARK model description of learning styles and gender

Learning styles are individual factors of difference that reflect enduringly on solutions regarding information processing. Although there are several conceptual models of learning styles, this paper adopts the model created in 1987 by Neil Fleming [20]. The model identifies four primary types of learning styles, the initials of which are used to name the model, i.e., VARK consisting of the following:

- ***Visual:*** learners prefer presentations and can understand from explanations;
- ***Aural:*** learners learn by hearing, they prefer aural guidance;
- ***Read/Write***: learners take notes, and learn best by reading; and
- ***Kinesthetics:*** learners learn better by doing. They like to get hands-on activities.

The preferences of the above-described learning styles differ in online courses and traditional face-to-face learning environments. Online learning systems usually have less sound and/or verbal portions than conventional face-to-fact lessons and thus are more capable of reading and/or writing tasks [30]. Students with visual and read/write preferences typically perform better in online classes than in face-to-face lessons [31].

There is a general notion that learning is an individual process, but there are patterns of learning style preferences indicating a significant relationship between the genders of students and learning styles: female students generally prefer aural guidance and prefer learning by hearing, therefore are to be perceived as Aural learners; in contrast, male students prefer to get hands-on activities, therefore the Kinaesthetic learning style is better suited for them [32].

Among other aspects of teaching and learning, learning styles are seemingly a tool to understand the apparent gap between male and female students in STEM courses [33]. The differences in learning styles preferences could also explain how gender impacts future job preferences, especially jobs related to STEM disciplines. Thus, identifying the preferred learning style during the lifecycle of studying can help the teacher adopt different students' styles to become more familiar from an earlier age with the best-suited learning style to their individual preferences [44]. To improve students' motivation and performance, especially for STEM courses, which are perceived as being more complex and harder to complete, teachers have to adapt their approach to (i) meet students' individual needs; (ii) take into consideration the gender-based preferences regarding learning styles; and (iii) motivate female students by trying out different learning styles.

3 Material and methods

This paper continues the task of identifying whether a gender gap in STEM courses exists. It also undertakes to understand whether the differences between genders we see in traditional face-to-face STEM courses are also present in online courses [9, 18]. While also focusing on

two different indicators such as character traits and learning styles, and how these correlate and differ based on gender, and if they influence students academic achievements.

3.1 Method

In our case study, data from undergraduate students enrolled in two STEM e-learning courses at the Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University in Skopje, North Macedonia were collected and analysed. The revised NEO personality inventory (NEO-PI-R) [35] where students could choose in between a range of 0–10 how they think score on a particular traits and the VARK online questionnaire which had a range from 0 to 15 where students could assess themselves which style they think learn best. The questionnaire were instructed on their experiences with the two online courses. During the experiment, the Moodle interactive interface was used for both student-content management and teacher-content interaction. During one semester, all participants took two online courses:

(i) Search Engines (the "C1 Course") with a lower level of difficulty, and
(ii) Dynamic Websites (the "C2 Course") with a higher level of difficulty.

Table 1 shows the initial number of students who began the case study was 155 with an average age of 19 to 21 years, with 61 female and 94 male students participating. The VARK questionnaire was completed by 97 students, and the Big Five questionnaire was completed by 96. The total number of students who did not complete the case study was 101, with 74 male and 27 female students. In total, 54 students finished the case study and took the final exam (34 females and 20 males).

The case study was completed with a final exam, through which students' learning outcomes were further evaluated. Students were divided into two groups of equal size: Groups A and B, each with 27 students (see Fig. 1). Group A students enrolled in the C1 Course were asked to select their preferred type of learning materials, while the course instructor assigned the type of materials delivered to Group B. The opposite practice was used for the C2 course, in which group B students chose learning materials while group A students were assigned the delivered materials by the instructor [26]. The educational content for each course was provided in three different e-learning methods and corresponding materials, which are summarized briefly below:

(i) *Online video conferencing (VC):* The professor provided the lesson in real-time, and learners were able to participate directly. During the presentation, learners were granted the chance to communicate with the instructor and with each other. Every student had to adapt to a predetermined class schedule.

Table 1 Case study – outcomes breakdown

Category	Female	Male	Total
Initial no. of students	61	94	155
No. of VARK tests performed	45	52	97
No. of Big Five tests performed	46	50	96

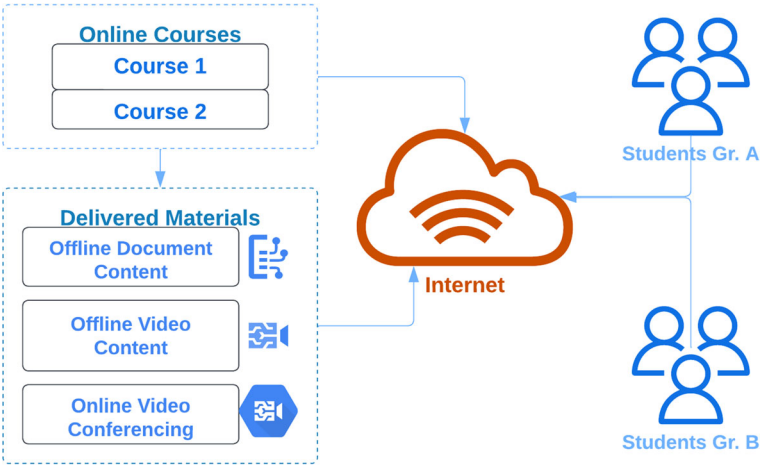

Fig. 1 Use case scenarios for the online courses [24]

(ii) *Offline video content (*VS*):* The professor recorded himself/herself delivering the lesson, and then uploaded the recording to a website accessible only for students. Students were able to study at their own speed and individual set timetable.
(iii) *Offline document content (PDF):* Students received only materials in the form of offline documents, where they had to study alone without a professor's explanation about the given topic.

Besides the indicators of learning styles and character traits, we analysed students' academic achievements in the traditional learning environment and in the online environment, based on two factors:

(i) *GPA-* which is the cumulative grade point average students have gathered mostly from traditional learning environment
(ii) *Test results-* which shows the academic success of students only during the two given online courses

3.2 Data analysis

We have used two different analysis for investigating how character traits and learning styles are related with gender and the different materials delivered:

Box plot analysis The boxplot data analysis method of data processing was used to determine the output of our case study samples. It is a systematic method of showing data distribution based on the five-number summary: minimum, first quartile, median, third quartile, and maximum. The boxplot approach to visually represent the distribution of data was especially used to (i) explore the relationship between the character traits and gender of the students; and (ii) compare the various datasets, greater distance in the diagram correspond to greater distance between numeric values [57]. Based on this approach, an analysis of the case study outcomes

from a gender perspective was conducted, focusing on how learning styles and character traits interacted with the cor'elation' correlation *relation analysis*: We have used the Pearson correlation coefficient, which measures linear correlation, where the value is a number between −1 and 1 that quantifies the relationship between two variables in terms of its strength and direction [45]. Correlation analyses revealed a variety of important associations between character traits and learning styles based on gender. First, we examined how students' perceptions of materials during online classes were spread according to traits, learning styles and gender. As mentioned above, the educational content was presented in three different methods, to see how students react based on gender according to their character traits and learning styles. Finally, we analyse the correlation of gender, Big Five traits, learning styles with the achieved academic success for the traditional learning environment and online learning environment. Established on the findings procured by using these frameworks and models, a correlation analysis was done to identify how male and female students differ based on character traits learning styles and different materials delivered. Different content types for the online courses were offered to evaluate the students' responses based on their gender, learning style and character traits as well as to identify the correlation of these three indicators with the overall academic success GPA (which is based on traditional courses) and Test results (which is based on online courses).

3.3 Results

3.3.1 Box plot analysis

Box plot analysis has been used to identify the associations between Big Five character traits and gender, Fig. 2 shows for each character trait how they differ for male and female students. Where the x axis shows the scale from 0 to 10, how students evaluated themselves for the given character and on the y scale we can see the difference between gender. The red squares represent female students, where the blue squares represent male students.

Table 2, summarizes and analyses the different character traits focused on gender, and which of them is more notable for male or female students:

Figure 3 represents a box plot analysis of learning styles and gender, the same initial method as stated above was used, where we analyze each learning style in relation to gender, and identify which learning style is more favored by male and female students. In figure three the x axis shows the range from 0 to 15, a scale set earlier in the questionnaire and the y axis shows the difference between male and female students. Table 3 summarizes an analyze of each given learning style in relation to gender.

3.3.2 Correlation analyses

Correlation analysis has been used to identify links between character traits, learning styles, online teaching modalities and gender. The scale for character traits and teaching modalities is shown in a range from 3 to 5.5 where based on the color, dark grey indicates the lowest correlation and dark blue indicates a higher correlation. The same sample has been used for learning styles and teaching modalities, where the scale on the y axis is from value 4 to 10 based on the scale from the questionnaire. Firstly we have generated a correlation analysis of those given indicators in associated to male students:

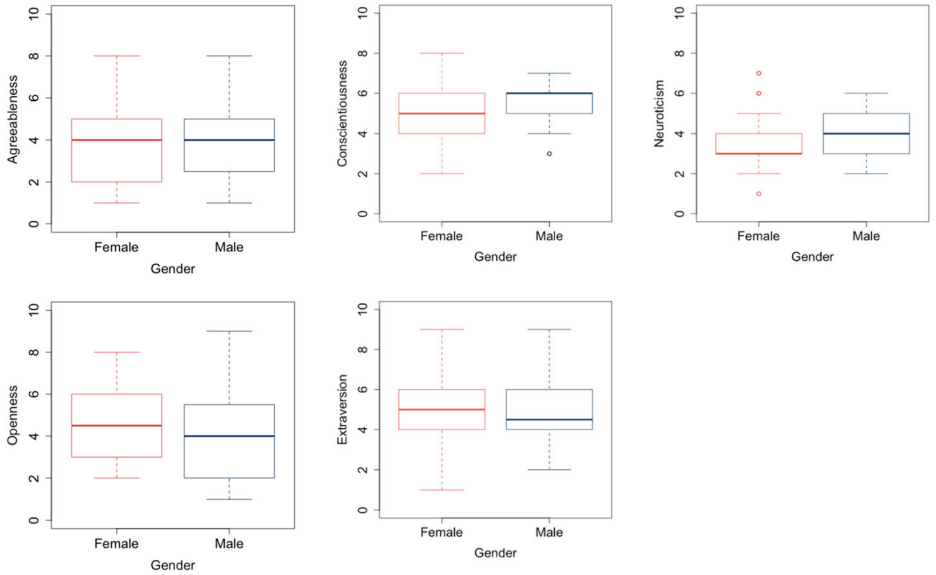

Fig. 2 Box plot sample analysis- character traits and gender

VS- this form of provided material shows a correlation with all character traits for male students, with a higher correlation for the trait of Conscientiousness and a less visible correlation for the trait of Agreeableness. Learning styles also show a strong correlation with this type of provided materials, with a higher correlation for Aural and Kinaesthetic.

Table 2 Character traits analysis

No.	Character Trait	Summary Analysis
1.	Agreeableness	Each of the statistics (median, UQ, LQ) for both genders is very similar. The median is the same, where the female graph is clustered between the median and the UQ. The male graph is equal clustered for UQ and LQ, which indicates that the distribution of values is narrower for male students.
2.	Conscientiousness	The distribution of data is very diverse, the box plot for female students is taller, which indicates female students gave a wider range of opinions. In comparison, the box plot for male students is shorter with a higher median, suggesting that male students are more compact for this trait. Based on the statistics, the median of the male graph is higher, and the data is clustered in the LQ, with one outlier, while the female graph is more distributed with higher minimum and maximum values.
3.	Neuroticism:	The data distribution of Neuroticism is very different, where the box plot for female students' values are in a higher range and has a positive skew, while for male students the range is smaller. The female graph is clustered in the UQ, with a lower median than male students, but we can observe 2 outliers. It indicates that male students scored higher for this trait in our case.
4.	Openness:	This trait is characterized with a compacter box plot for female students and a higher median, while male students' box plot is characterized with a negative skew and wider range of values.
5.	Extraversion	Both box plots for male and female students have a similar data distribution, for female students with a higher median, and almost equal data distribution for LQ and UQ. As the male graph has a lower median, clustered in the UQ. It appears that female students score higher for this trait

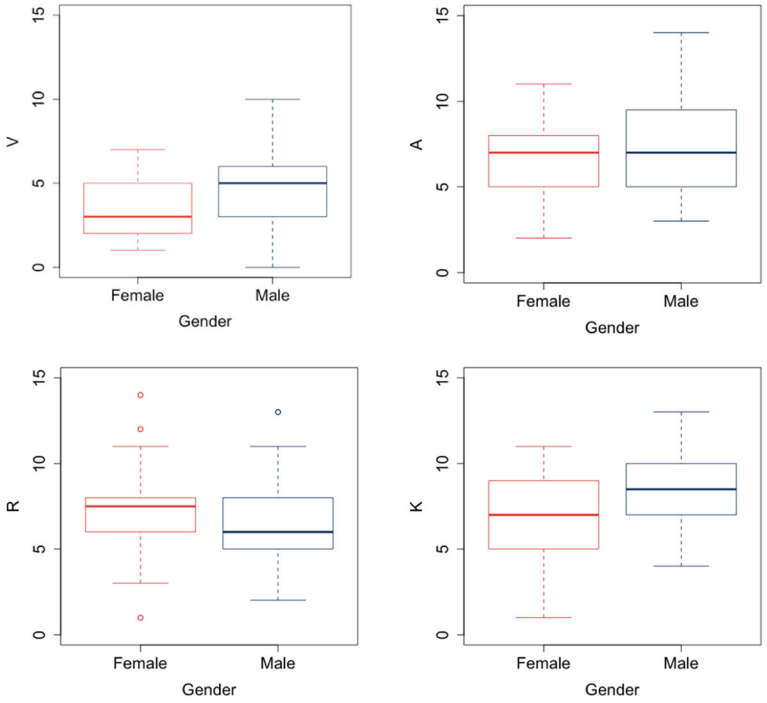

Fig. 3 Boxplot analysis - learning styles and gender

VC- this type of provided materials shows similar correlation with the Big Five traits as the material provided VS, Conscientiousness followed by Extraversion have a stronger correlation, and a lower degree of correlation we can identify again for the trait of Agreeableness. While learning styles also are very similar correlated like with VS, where Visual shows a weaker correlation at all, with a higher correlation for Aural and Kinaesthetic.

Table 3 Learning styles analysis

No.	Character Trait	Summary Analysis
1.	Visual (“V”)	Based on the statistic for both genders, we can observe that the graphs show a different distribution of data. The minimum and maximum values for the male graph are more distributed than for female students. The median is higher for male than female students, which indicates that male students prefer more the V style than female students.
2.	Aural (“A”)	The statistics show a different distribution of data, with a higher maximum for male students and a similar median. The female box plot has a negative skew, while for the male graph both quartiles look similar, with a higher number of outliers. This indicate that male students prefer more the aural style.
3.	Read/write (“R”)	The data distribution is very different for the trait of R, the female graph is denser with a higher median and 3 outliers. While the male graph has a lower median and the UQ is more compact, this indicates that female students prefer this style more.
4.	Kinesthetics (“K”)	The data distribution for the male box plot shows higher values for all statistics, like minimum median and maximum, which indicates that male students prefer this style more than female students.

PDF- This form of provided materials differs mor from the two above stated since here students get only offline documents, for the Big Five traits only Agreeableness shows no correlation while Conscientiousness again is the most correlated trait, and as for learning styles Kinesthetic and Aural shows a higher correlation, where Visual shows a weaker correlation.

Figure 4 continues with the same method of analyze as Fig. 3, but here we display the correlation of traits learning styles and teaching modalities based on female students. The color red here indicates a strong correlation, where the color grey indicates a low correlation (Fig. 5).

VS- this form of provided material shows a correlation a higher correlation for the trait of Conscientiousness and a less visible correlation for the trait of Agreeableness, while no correlation for the trait of Neuroticism is evident. Learning styles also show a strong correlation with this type of provided materials, with a higher correlation for Aural and Kinaesthetic, and weaker correlation for the style of Visual.

VC- this type of provided materials indicates a stronger correlation with all character traits, only Neuroticism shows a weaker correlation. While learning styles also are very similar correlated like the previous material VS, where only Visual shows a weaker correlation.

PDF- This form of provided materials differs more in the form of content, for the Big Five traits Neuroticism shows no correlation, Conscientiousness and Extraversion show a higher degree of correlation, while for learning styles Visual shows the weakest correlation and Read/Write the highest correlation.

Subsequently we have generated a correlation analysis for all indicators mentioned in Fig. 6, where we wanted to point out how they influence academic success, we focus on two different indicators *GPA* and *test results*. GPA is the grade point average accumulated during face-to face classes, this will specify students success in traditional classes, while the other indicator test results, specifies the results students achieved during the two online classes, which will be our indicator of students success only in online classes.

Two colors have been used to show positive and negative correlation, dark orange indicates a higher positive correlation while dark grey indicates a negative correlation, and the sizes of the circles show a strong or low correlation. All indicators are integrated on both axes, so that

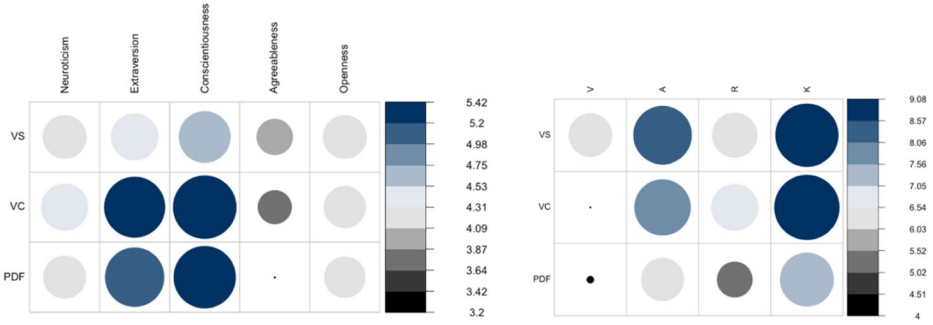

Fig. 4 Correlation of big five with materials del. & VARK with materials delivered - male students

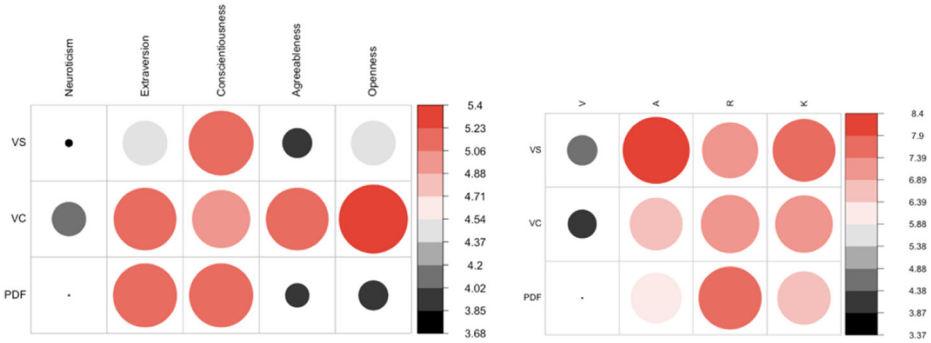

Fig. 5 Correlation of big five with materials del. & VARK with materials delivered-female students

we can visualize better the correlation of traits, character traits and gender with GPA and test result.

(i) Test results correlation

The indicator of test results shows the state how styles traits and gender affect STEM online classes. Big Five traits show a milder correlation in contrast to GPA, only Extraversion has a

Fig. 6 Test results and GPA correlation with traits, style and gender

negative correlation, Neuroticism and Openness no correlation, Consciousness and Agreeableness show a positive correlation. All learning styles show a positive correlation with test results, only Aural shows a lower correlation, due to the fact that students are online.

(ii) Gender, GPA, Test results

The correlation of Gender with GPA and Test results shows some explicit gender differences in STEM courses, taken in traditional environment and online environment. GPA is negatively correlated with gender which meanes that female students have higher GPA, which is accumulated out of traditional courses taken, while the indicator of Test results is positively correlated with Gender, which means that male students score higher Test results during online courses.

4 Discussion

Based on the correlation analysis our research results point out some noteworthy connections of different variables significant in the academic success of students in STEM online classes. We have used two indicators to show students success, where GPA shows the overall success gathered by students in traditional classes, whereas Test results show the success only for the two online courses mentioned in the case study. We will further discuss the impact of Big Five/VARK/Gender in Test results, since these are based on achievements gained exclusively in online STEM courses.

The traits that were distinguishable from our case study as to having the most impact are Conscientiousness and Neuroticism. Based on our findings, male students' statistics show a higher percentage for both these traits, compared to their female counterparts [56]. The trait of Conscientiousness and Extraversion have the highest correlation with the different methods of delivery, meaning that there no differences based on gender could be identified. Hence, the correlations are to be understood as individual alterations [55]. Our research indicates individuals who score higher on the traits of Conscientiousness and Extraversion can adapt to any type of learning material provided to them [46]. It is also notable that female students, which prefer the provided material VC, score higher in Agreeableness and Openness compared to male students. Viewed from the perspective of learning styles, V (visual) is the style with the weakest correlation for both genders, due to students being online. The style of Aural seems to be more favored for male and female students, while hearing the lessons through VC and VS. The only gender differences for learning styles we can identify is that female students prefer more the style of Read/Write whereas male students like the style of Kinaesthetic [47, 58].

Identified correlations for GPA and test results GPA (assessment knowledge from courses in offline delivery) correlation indicates that the trait of Consciousness has the highest positive impact, where students which score high in this trait get better grades, while Neuroticism confirms that students which score higher in this trait have lower GPA's which also indicate the negative correlation. From the perspective of learning styles only the style of Aural is negatively correlated, while all other styles show a positive correlation with the highest correlation of Read/Write, which is very usual for traditional classrooms [54, 56]. The indicator of Test results show slightly different correlation for traits, styles and gender since

students were exclusively online, the correlation with traits are weaker where Consciousness has still the highest correlation level followed by Agreeableness and negative correlation with Extraversion which could be due to lack of students opportunities to socialise [51–53]. While it test results show a positive correlation with all VARK styles, especially with Visual and Kinaesthetic where it should be noted that students where taking STEM (Computer science) courses which also require task delivered online [48].

In our experiment the correlation of GPA and Test results with gender reviled differences in offline and online course delivery, while female students acquired higher GPA's meaning they exceed in traditional courses, male students achieve better academic results in online courses. These results are in line with other researches [49] that male students perform better in online courses, while female students which study STEM courses in traditional environments, finish their studies with even better results than male students [4]. What is also notable is that the correlation of test results with gender has a smaller value in contrast to the correlation of GPA and gender, which indicates test results differ less than GPA's between male and female students. We also identified that character traits are more individually linked to academic achievement then gender, where the trait of Conscientiousness is a positive indicator not depending on the gender, where learning styles are more gender divided [50]. Further research is needed to take into account other indicators which may cause female students to gain weaker results than male students during online courses.

5 Limitation of study

The sample selected for this study was specifically students who were studying computer science and engineering, with a small number of a sample. The results obtained in this study may not be applicable to students outside of this designation. While narrative research is considered appropriate for research, persons experience may limit the representations of multiple viewpoints. Future research is needed while analyzing a broader sample, where the participants would have different educational backgrounds linked to STEM, earlier stages of education and also take into consideration other factors that affect gender differences like demographics, education level of family, age.

6 Conclusion

In this paper we are looking how gender impacts the academic achievements in online classes compared to traditional classes, with a specific focus on learning styles and character traits. Based on our data the trait of Consciousness is a stable predictor of students' engagement in online courses, no matter the method presented or gender, where the trait of Extraversion shows negative correlation due to the fact that students who are more sociable feel more isolated in online learning. Also, the trait of Neuroticism's shows less correlation with both gender for all methods of delivery, nevertheless it has no negative impact in students' academic achievements during online classes, in contrast to traditional learning environments. These results indicate that character traits do not show a gender based pattern, but are more individually related.

Learning styles show a gender based pattern, where the style of R(read/write) is correlated with all delivered materials for female students, while on the other hand K(kinaesthetic) is the

most persistent style for male students, where all styles expect of A(aural) have positive relation with online courses examinations.

The findings of our case study indicate that gender can be seen as an indicator between traditional learning environment and online environment, where women are enthusiastic individual learners who are academically engaged and can (out)perform their male counterparts in traditional STEM courses, while online they show slightly weaker results than male students, even though a higher percentage of female participated in this case study. Further investigation is needed to be able to extend the conclusion in general scenarios, where other factors have to be analysed like access to technology, course difficulty and social background.

It is crucial for academic departments and institutions to recognize and acknowledge the traditional systemic barriers in STEM that continue to marginalize women. To address these barriers, STEM departments might use their networks to reduce the gender inequality in STEM education areas, as a doorway to increase jobs and competitiveness for women, mitigate workplace discrimination, and boost technical capacity growth. Traditional science training provides a solid foundation of facts and basic science technique, but rarely examines how to foster scienti creative, cross-disciplinary problem identification and solving skills. By using interdisciplinary practices STEM has been enhanced to STEAM that includes art as a means of inclusive integration. This should create an infinite number of opportunities for indiscriminate initiatives at both the individual and institutional levels.The implementation of STEM education through STEAM (science, technology, engineering, arts, mathematics) lends itself to interactive and participatory dialogic art; this juncture provides a nonjudgmental space to cultivate the question-making aspect of inquiry, the ability to comfortably hold uncertainty, and sensitivity to the process of discovery [4]. While STEM (Science, Technology, Engineering, and Mathematics) education alone does not guide females into environments where leadership is encouraged and mentored, research does suggest the benefits of adding the 'Arts' to STEM in order to further positive workplace investment. The future works would incorporate a higher sample of participants within different study programs in the STEM field, while analyzing also different indicators which lead to gender differences and their academic achievements.

Data availability The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interests The authors did not receive support from any organization for the submitted work. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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