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Comparing Blended E-Learning and Conventional Classroom Methods in Teaching the Basic Statistics Subject

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ABSTRACT

Blended e-learning is a highly interactive approach. This study explores the effectiveness of blended e-learning in teaching statistics compared to the conventional classroom. A retrospective record review using the final assessment score data was conducted. A total of 111 students from the advanced diploma programmes who attended the Basic Statistics class from the blended e-learning group and conventional classroom were recruited by universal sampling. Descriptive data were presented in mean (standard deviation) and frequency (percentage). Univariable analyses used the independent samples *t*-test and Pearson's chi-squared test. Factors influencing the final assessment score were analysed using simple and multiple linear regression. A value of $p < 0.05$ was considered statistically significant. The finding showed that students who underwent blended e-learning teaching methods had a significantly higher assessment score than conventional classroom methods—88.78% and 81.90%, respectively. The assessment score was significantly reduced by 1.14 with an increase in age in this study. The multiple linear regression showed that age and teaching methods were the significant predictive factors of the assessment scores. Students in the blended e-learning group had a seven times higher assessment score compared to the conventional classroom (with a regression coefficient of 7.43 [95% confidence interval 3.61, 11.25]; $p < 0.001$). In conclusion, the blended e-learning method was shown to be more effective in teaching and learning the Basic Statistics subject, with its ability to cater to students with different learning speeds. Transformation in teaching methods is crucial to improving the teaching and learning experience and quality of education.

Keywords: *Blended learning, E-learning, Conventional classroom, Teaching, Basic statistics subject, Teaching-learning method*

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INTRODUCTION

Globally, the epidemic of COVID-19 has disturbed traditional classroom instruction. In order to ensure the continuity of study, educational institutions were forced to quickly adapt to and create a new educational environment by implementing remote and e-learning (1). The new teaching strategies incorporating digital resources into the teaching process extensively utilise digital technologies, particularly internet technologies, to provide individually tailored or dynamic courses (2–6). Tools for connecting teachers and students for synchronous activities that can be done from a distance have also become the standard for blended learning designs (7). Overall, this digital revolution has helped to increase the number of educational opportunities, improve the quality of education, and make tertiary education more affordable (8).

Conventional Classroom, Online Learning, and Blended Learning

The conventional classroom teaching method, or face-to-face learning, involves the teacher standing in front of the students to deliver the lessons; in contrast, the participants pay attention, annotate, and remain passive throughout the whole lesson (9). Typically, this instructional format requires the physical presence of all participants (educators and learners) in a classroom setting, which increases the pressure on students and makes them more responsive to adapting to contemporary students' daily life (3, 10). In contrast with traditional learning, online learning is commonly defined as the absence of a classroom setting, which is overtaken by digital technology to enable independent learning outside the classroom (11–14). Typically, virtual learning environments (VLEs) or learning management systems (LMSs) are used to launch online education, permitting students to learn independently at their own pace, location, and time (15). However, blended learning integrates in-person physical classroom sessions with online content and instruction (16). Blended learning offers a variety of instructional strategies and generally involves instructor-led training with proven efficacy (17). The combination of diverse teaching methods and media options enables educators and facilitators to accommodate and engage students with varied learning preferences and styles (10, 16).

Blended e-Learning

Blended e-learning is an amalgamation of modern trends with increasing importance in the educational process. It represents a new educational environment that combines the benefits of e-learning and classroom instruction, contributing to the advancement and achievement of educational goals (18). It is a highly effective strategy that combines synchronous remote online and face-to-face classroom learning with asynchronous e-learning. Asynchronous learning entails online self-study via an LMS; conversely, synchronous meetings are held virtually with the instructor via Zoom/Skype/Google Meet video conferencing (19, 20). Blended e-learning methods replace instructor-led face-to-face training with virtual instructor-led training (VILT) with equivalent results. A previous study showed that blended e-learning could be used for most academic subjects, both theoretical and practical (18).

Due to the epidemic of COVID-19 and the evolution of teaching and learning methods, numerous studies have sought to determine if computer-mediated education in e-learning, blended learning, or hybrid learning is superior to traditional classroom instruction in terms of student satisfaction and learning outcomes. Blended learning has been shown to be a superior method for teaching undergraduates, as demonstrated by the improved performance of students who were exposed to blended learning over those taught using e-learning and conventional methods (9). Furthermore, in the health professions, blended learning

has shown a more significant and consistent positive impact on knowledge acquisition than traditional learning (21).

Teaching and Learning in Statistics

Statistics is a fundamental subject in medical and health science (22). Statistics and research are two essential components for future health sciences personnel to enable them to understand and be involved in research activities and, thus, apply evidence-based practice (23). Teaching and learning in the subject of Basic Statistics typically consist of lectures and numerous hands-on sessions of computer software usage guidance, typically delivered in a traditional classroom setting (24). Students frequently have trouble learning, comprehending, and applying statistics, resulting in poor performance in this subject (25). The effectiveness of teaching the subject relies on a teacher's knowledge and skills, as well as the methods and media used.

Blended e-learning has been shown to be effective for teaching practical subjects that require repeated skill practice. During the COVID-19 pandemic, when classroom training was no longer an option for large remote workforces, blended e-learning and virtual instructor-led training replaced face-to-face instruction. Recently, more statistics courses implemented in the blended e-learning mode have also been made available through online platforms to accommodate the needs of students with distance-learning and part-time schedules. However, the implementation and effectiveness of blended e-learning, particularly in teaching practical hands-on Basic Statistics, has been infrequently discussed. Therefore, this study aimed to evaluate students' performance in the subject using blended e-learning compared to conventional classroom methods and explore the factors influencing the students' performance in Basic Statistics.

METHODS

Study Design

The present study has a comparative cross-sectional design involving a retrospective record review. Thus, we retrospectively examined and compared the Basic Statistics subject assessment scores between students who attended blended e-learning and conventional classrooms.

Participants

This study included all advanced diploma programme students who successfully attended the Basic Statistics subject class and completed the assessment within the study period. Students who attended the class from 1 September 2019 to 29 February 2020 and from 1 March 2020 to 31 August 2020 were assigned to the conventional classroom teaching group and blended e-learning group, respectively. This study excluded students who were on certified medical leave for more than 14 days, withdrew from an advanced diploma programme before the assessment, or did not complete the assessment.

The sample size calculation in this study was based on a *t*-test study in the Power and Sample Size Programme, version 3.1.6, U.S. (26). The parameters used are from a previous study in which the mean difference in students' learning achievement scores in the experimental and control group was 5.86, with a standard deviation of 8.845 (27). We set the probability of correctly rejecting the null hypothesis of equal population means, with power = 0.90, a Type I error probability, $\alpha = 0.05$, and the ratio of one control subject with one experiment subject; the minimum required sample for each group was calculated as 49 subjects. However, as this is a retrospective record review and the required sample size was small, we included all eligible students

to participate in this study to prevent a lack of power. A total of 111 students from the following two advanced diploma programmes were recruited: Advanced Diploma in Health Management and Advanced Diploma in Emergency Care. Sixty students were in the conventional classroom teaching group, and 51 were in the blended e-learning group. The details of the conventional and blended e-learning teaching methods in this study are outlined as follows:

Conventional classroom

The instructor used the presentation material as stated in the syllabus and followed the face-to-face lecture and practical lesson for the hands-on session for computer analysis. The learning materials for students were in hard copy, and students were free to seek mentoring after class via WhatsApp. At the end of the Basic Statistics class, the students were assessed using the assessment questions in the syllabus guideline. The exam date for the conventional classroom was 1 October 2019.

Blended e-learning classroom

The instructor employed the same presentation material for the conventional classroom and the virtual face-to-face class (synchronous session) using an online meeting platform (Zoom conference meeting). The virtual face-to-face practical class for the hands-on session for computer analysis used the same online meeting platform. All the video recordings of the "live" (synchronous) sessions and learning materials were uploaded and available 24/7 for access via Google Classroom for self-learning (asynchronous sessions in the LMS). As in conventional classroom groups, students could seek mentoring after class via WhatsApp. At the end of the Basic Statistics class, the students were assessed using the same assessment questions as in the conventional classroom group. The blended e-learning classroom's exam date was 1st April 2020. The participants' final assessment scores comprised the primary outcome in assessing blended e-learning and conventional classroom performance.

Test Instruments

A set of hands-on test questions that included all syllabus topics was used to assess the students' performance in the Basic Statistics class for both the conventional and blended e-learning classroom groups. Both groups of students were given a research study scenario with five study objectives. They had to plan for analysis, decide on suitable statistical tests, run the analysis using statistical analysis software, present the data, interpret the findings, and draw a conclusion. The assessment included learning outcomes for data entry, coding, labelling, exploring, cleaning, computing, recording, analysing, presenting, interpreting, and drawing conclusions. The validity of the assessment questions was determined by two subject matter experts who taught the course according to the course module syllabus and learning outcomes. An item analysis was performed with 65 students. The discrimination indices and the reliability of the assessment were checked using the Point-Biserial coefficient and Cronbach's alpha, respectively. All items showed good discrimination indices ranging from 0.444 to 0.887, while the assessment set showed good reliability with a Cronbach's alpha of 0.826.

The assessment was conducted physically in the conventional classroom, whereas in blended e-learning classrooms, the assessment was conducted online with video facilitation. Students in blended e-learning were required to turn on their audio and video in Google Meet during the whole assessment session, and the session was recorded for quality checking. The students' responses were submitted in a data file, output file, and Word or PowerPoint file through Google Classroom (blended e-learning group); or a soft copy to the assessor directly in a digital optical disc

storage format, compact disc-rewriteable (CD-RW) individually (conventional classroom group). The assessor assigned marks to the submitted answers according to the detailed answer scheme by section. The final assessment scores were entered into the Microsoft Excel spreadsheet.

Data Collection Procedures

The 111 students' data was obtained from the Evaluation and Quality Unit, Institut Latihan Kementerian Kesihatan Malaysia Sultan Azlan Shah, Selangor, Malaysia. The data extracted included age, gender, race, advanced diploma programme(s), and assessment scores. The confidentiality of the assessment scores released for this study was maintained, and no data was disclosed to third parties.

Data Analysis

In this study, data analysis was performed using SPSS version 22 software. The descriptive data were presented in mean ± standard deviation (SD) and frequency (percentage). The mean assessment score was compared using the independent samples *t*-test. Correlations between age and assessment score were identified using Pearson's correlation. The simple and multiple linear regression analyses identified the influencing factors of students' performance. All three forward, backwards, and stepwise multiple linear regression methods were compared and showed the same number of variables and significant variables in the models. The assumption was checked for normality (independent *t*-test) and found to be met. For the multiple linear regression assumptions, multivariate normality, residual normality, homoscedasticity, collinearity, and multicollinearity were checked and found to be met. A value of $p < 0.05$ was considered statistically significant.

RESULTS

One hundred eleven students from the advanced diploma programmes were included in this study, comprised of 60 students (54.1%) in the conventional classroom and 51 students (45.9%) in the blended e-learning environment of the Basic Statistics course. The students' ages ranged from 24 years old to 47 years old, with a mean of 30.50 ± 4.73 years. The overall mean score of the assessment was 85.06 ± 11.88, which ranged from 42.5 to 99.24 marks. More than half of the students in this study were female (58.6%) and Malay (90.1%); 82.9% were from the Advanced Diploma in Emergency Care Programme. The comparison of the characteristics of the respondents for both groups showed no significant difference (Table 1).

The comparison of student assessment scores between teaching methods in this recent study showed that students who underwent blended e-learning teaching methods had a significantly higher assessment score in the Basic Statistics subject than students who underwent conventional classroom teaching methods—88.78% and 81.90%, respectively (Table 2). This study also explored the other influencing factors of Basic Statistics performance, including age, gender, race, and the advanced diploma programme. The correlation between students' age and the Basic Statistics assessment scores showed that the increase in age caused a significant reduction in the assessment scores in this study ($r = –0.44$, $p < 0.001$). Meanwhile, students from the Advanced Diploma of Emergency Care Programme had significantly higher assessment scores than those from the Advanced Diploma of Healthcare Management Programme—86.82% and 76.58%, respectively. However, students of different genders and races did not show significant differences in terms of assessment scores.

Table 1: Characteristics of the respondent according to conventional and blended e-learning teaching methods

Variables	Conventional (*n* = 60)	Blended e-learning (*n* = 51)	*P*-value
Age (mean, SD)	30.28 (5.43)	30.76 (3.77)	0.585*
Gender			
Male	28 (25.2)	18 (16.2)	0.251**
Female	32 (28.8)	33 (29.7)	
Race			
Malay	54 (48.6)	46 (41.4)	0.614**
Non-Malay	6 (4.5)	5 (4.5)	
Programme			
Emergency care	49 (44.1)	43 (38.7)	0.803**
Health care management	11 (9.9)	8 (7.2)	

Note: *Independent *t*-test applied: Levene's test for equality of variances: 0.025. Equal variances are not assumed. Variable ages were normally distributed. **Pearson Chi-square test applied: 0.0% cell have expected count less than 5.

Table 2: Influencing factors of student's performance

Variable	Mean (SD)	Simple linear regression		Multiple linear regression‡	
		Coefficient	*P*-value	Coefficient (95% CI)†	*P*-value
Age		–1.10 (–1.53, –0.67)	< 0.001*	–1.14 (–1.54, –0.73)	< 0.001*
Teaching and learning methods		6.88 (2.57, 11.19) Reference	0.002*	7.43 (3.61, 11.25) Reference	< 0.001*
Blended e-learning	88.78 (10.78)				
Conventional classroom	81.90 (12.16)				
Gender		1.02 (–3.54, 5.57) Reference	0.660		
Male	84.64 (13.12)				
Female	85.66 (9.97)				
Advanced diploma programme		10.24 (4.61, 15.87) Reference	< 0.001*		
Emergency care	86.82 (9.89)				
Health care management	76.58 (16.62)				
Race		3.47 (–4.01, 10.96) Reference	0.360		
Malay	85.41(11.81)				
Non-Malay	81.94 (12.66)				

Note: *$p < 0.05$; †95%; CI: 95% confidence interval. ‡Multiple linear regression forward methods applied. All forward, backward and stepwise model shows the same number of significant variables. Adjusted *R*-square: 0.276. The normal Predicted Probability (P-P) plot of regression standardised residual shows that residuals are normally distributed, normality assumption is met. The scatterplot of the residuals shows no heteroscedastic pattern, homoscedasticity assumption is met. Collinearity was checked and found no multicollinearity (Variance inflation factor, VIF = 1.0003).

The multiple linear regression analysis found two significant influencing factors of the students' performance in Basic Statistics (Table 3). The final model using the forward method included age and teaching methods as significant predictors (F [df] = 21.94 [2, 108]; $p < 0.001$; adjusted R-square = 0.276). The findings showed that students in a blended e-learning classroom had seven times higher assessment scores than those in a conventional classroom. An increase of one year in student age was also shown to reduce the assessment score by one unit. However, this model with two variables explained only 27.6% of the variation in students' assessment scores in the Basic Statistics subject.

DISCUSSION

This recent study showed a substantial performance gap between the blended e-learning and conventional groups. The blended e-learning group scored better than the conventional classroom group in the subject of Basic Statistics. This result is in line with the researcher's hypotheses and previous research, which concluded that blended e-learning is superior to face-to-face or e-learning alone (28, 29). A meta-analysis also reported that blended and purely online learning result in similar student learning outcomes (30). Furthermore, blended e-learning has been shown to improve exam scores and academic achievements compared to face-to-face learning (31).

Small but significant gains in student achievement appear to result from incorporating technology into blended learning courses, particularly in terms of providing cognitive support, such as simulations, and facilitating student engagement (12). A previous study suggested that e-learning should be based on graphical instruction and independent learning (32). Leveraging instructional media in a blended e-learning environment will further intensify achievement (33). The practical aspects of blended e-learning should be incorporated into the online setting through relevant visual materials, virtual reality, and simulation modelling. Another review also reported that blended learning is more efficient and effective in delivering instruction to the intended students through programmed instruction (PI) or computer-assisted instruction (CAI) (34). The blended e-learning method can divide the instructional content into tiny pieces according to topics and learning styles, making the content easier to understand (33). Moreover, the individualised instruction approach in blended e-learning also considers the individual's learning and cognitive styles, meeting the student's characteristics, needs, and learning styles and improving the effectiveness of the education and training (33).

A blended e-learning setting can provide a productive platform for student-teacher interactions (35). It allows the students to access the lesson materials and videos before the class, which helps them prepare before the learning session (35). Blended e-learning activity enables students to work at their own pace, allowing them to revisit the online materials, videos, and lectures to master the competencies prior to assessment. Furthermore, instant feedback from online performance tests facilitates students in monitoring their learning progress and indirectly cultivates their awareness of the central role of their learning achievement (36). Blended e-learning provides an improved balance between a learner's desires and the programme's offerings, enhancing overall education proficiency (37).

Due to the outbreak of the COVID-19 pandemic, blended e-learning has been unavoidable and has become a better method for teaching, including the subject of statistics. Blended e-learning is preferable because face-to-face and e-learning methods can complement and supplement one another to improve

existing teaching and learning methods. Aside from that, integrating face-to-face and real-time learning with online digital resources offers students flexibility in managing their learning process in terms of space, time, and ease of access (38). The flexibility offered indirectly promotes better academic motivation (39).

However, other studies have shown contradicting results favouring e-learning and conventional methods (29, 33, 40). Previous studies on hybrid introductory courses in microbiology and psychology found less successful and decreased exam grades than in face-to-face versions (41, 42). Less physical contact due to less class attendance and loss of sense of belonging in class were potential reasons for the lower achievement (10). Meanwhile, a lack of clear and specific face-to-face instruction when dealing with complex concepts independently in hybrid courses has been shown to contribute to poor performance (42). In addition, previous research has suggested that low achievement in blended learning may result from an e-learning design that emphasises theory over practice (33). Moreover, the effectiveness of blended learning may depend on other factors such as student characteristics, design features, and learning outcomes (43).

Online assessments are often said to be easier to score but have less validity in terms of academic integrity (44). In this study, using different modes of assessment (face-to-face and online) may also have impacted assessment outcomes. However, according to a previous systematic review study, the performance of students on the final examination did not differ significantly between online and traditional examination modes (45). Nonetheless, a study comparing proctored and non-proctored online examinations also discovered no significant differences in multiple dimensions, including test-taking behaviours (46).

Factors Influencing Student Performance

This study explored factors influencing student performance in Basic Statistics based on gender, age, race, advanced diploma programme, and teaching methods. The findings showed that students in a blended e-learning classroom had higher assessment scores than those in a conventional classroom; furthermore, the older students had lower assessment scores. However, gender, race, and types of advanced diploma programmes did not influence students' performance in this study. Aside from that, the findings of this study showed that student age as well as the teaching and learning methods used were the two significant predictors of student performance in Basic Statistics; this explained 27.6% of the variation in student assessment scores.

Student ages significantly predicted the assessment scores in the Basic Statistics subject, and the younger students had better performance than the older students in this study. A previous study focused on teaching statistics reported that a student's age and their ability in computing significantly affected their performance in this subject (25). Younger students are generally more computer literate than their older counterparts and have a better competency in performing statistical analysis using computer software. However, the findings of this study contradicted those of previous blended e-learning studies, which found that older students were more prepared and motivated to perform better in blended e-learning (47, 48).

Gender, race, and type of advanced diploma programme did not influence student performance in this study, which was consistent with previous studies (47, 49). Nonetheless, a study on the subject of statistics revealed that male students performed better than female students. The

study showed that female students usually underestimate their abilities and have more negative attitudes towards statistics subjects compared to male students, which may create an obstacle to learning this subject (50, 51). The confidence gap in female students impacts their academic choices, causing them to avoid scientific subjects and prefer non-mathematical subjects (52). Low self-perceived abilities and negative affect were associated with lower achievement among female students, whereas male students with better mathematical knowledge was the only significant predictor for higher statistics achievement (53).

Race has also been shown to be a determining factor for academic performance (54). A previous study evaluating the academic performance of pupils from various ethnic groups discovered that Chinese students outperformed Bumiputera students across all cognitive domains (55). A meta-analysis examining American and Chinese students also revealed that Chinese students had a higher performance in mathematics (56). However, in the current study, 90.1% of the students were Malay, and the number of Chinese students or students of other races was too few, making the comparison invalid.

In this study, different advanced diploma programmes showed no effect on student performance. Students in the current study were at the same academic level and with nearly the same professional background in healthcare and attended the same training institution. Consequently, the difference between the students was not significant. Previous research has demonstrated that proficiency in mathematics, research, and computers might impact performance in Basic Statistics (53). However, the students' knowledge level at the beginning of the course was equivalent to their educational prerequisites. Consequently, the difference was not noteworthy.

The two significant predictors of students' performance in Basic Statistics in this study explained 27.6% of the variation in students' assessment scores. This finding indicates that a few other factors may have also influenced the students' performance in the Basic Statistics subject. According to a previous study, the attitudes towards statistics, age of the students, type of university access, admission score, interest in the subject, and workgroup participation have a significant impact on academic performance (25, 53). Most students consider statistics to be a challenging subject to learn (25). In addition to cognitive factors, an individual's disposition is crucial in learning (51). Students' attitudes towards this subject have also been shown to be related to their involvement in work—for example, previous involvement in a research project may increase a student's motivation to learn statistics (57). Furthermore, students' interest in statistics also substantially affected their performance in this technical subject (58, 59).

Strengths of the Study

This study highlights a comparison between blended e-learning and conventional classroom methods regarding student assessment scores, specifically in the subject of statistics. Previous studies evaluating the efficacy of various teaching and learning methods have yielded mixed results. However, studies focusing on teaching statistics subjects are relatively rare. This study has reported that blended e-learning effectively taught practical sessions in statistics. Additionally, we also suggest two significant predictors of student performance in statistics, including age as well as teaching and learning methods.

Teaching and learning are evolutionary processes that change with time. The emergence of digital technologies has made teaching and learning activities a highly dynamic process, in which the conventional methods alone might seem incomplete. Thus, it is reasonable to suggest that this study's findings contribute significantly to the related studies. In addition, using quantitative data for analysis was an advantage of the present work, as this

type of data is consistent and reliable for analysis. The sample size of 111 students in this study represents the population as all students from both programmes who were included. High post-hoc power was calculated retrospectively in this study, showing that this finding is valid.

Limitations

This study compared blended e-learning and traditional classroom methods for teaching Basic Statistics using assessment scores; other teaching and learning methods were not considered in determining the best method for learning the subject. Different modes of assessment using the same tool between two compared teaching and learning groups could also result in biased findings. Aside from that, as this study has a retrospective design, exploring the influencing factors was limited and could be focused only on age, gender, race, teaching and learning methods, and advanced diploma programmes. Therefore, other factors that might influence the score assessment, such as personal computer literacy and individual learning abilities, perceptions, and attitudes, were not explored. In addition, the interpretation of this study's results was solely dependent on a statistical analysis of students' assessment scores between the two groups of samples in a single-centre study; generalisation to other populations must be done with care.

Recommendations

It would be fascinating to expand the sample size and the number of study centres to improve the generalisability of the findings, conducting a longitudinal study to determine if there is a significant difference in blended e-learning student performance. In addition, future research could investigate the efficacy of blended e-learning in teaching statistics by incorporating cognitive and psychological variables such as stress, perceptions, and attitudes.

CONCLUSION

Blended e-learning has become a better method of teaching statistics, as students can learn from home in a more flexible, comfortable, and convenient environment. The online platform provides 24/7 accessibility and unlimited video reviewing time for students who require more time to understand the content, especially for practical statistics lessons. Therefore, gaps between the fast and slow learners could be managed better in blended e-learning, as the students are responsible for their own learning. However, this freedom of accessibility in blended e-learning could not be achieved in conventional classroom teaching, as the instructor is limited to the provided hours for the subject. Moreover, blended e-learning in this study using Google Classroom as a platform enabled students to interact with the instructor and complete their assignments online, providing more opportunities for students to check their performance via instant feedback and submit relevant corrections, improving teacher-student engagement and thus boosting the students' learning motivations.

In conclusion, the findings suggest that blended e-learning could improve students' performance in learning practical statistics analysis. However, the effectiveness of blended e-learning implementation depends on student characteristics, environment, and motivation. More comprehensive integration of blended e-learning into diploma education will help further the transition towards competency-based education and lifelong learning among students, where educators are instead facilitators.

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ETHICAL APPROVAL

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