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Integrating new learning methods into equine nutrition classrooms: The importance of students' perceptions

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Abstract

Despite greater efforts made over recent years to teach animal nutrition to veterinary students, more needs to be done to develop teaching methods and improve education on equine nutrition. The flipped classroom and peer-assisted learning (FC/PAL) approach is a teaching technique suggested to support learning; however, research into FC/PAL in veterinary education is scarce and little is known about students' views on this approach. This study examined the results of a questionnaire administered to assess veterinary students' perceptions of/views about the suitability of FC/PAL applied in an equine nutrition course. Correlation analysis of students' responses to questionnaire items and principal component analysis (PCA) was performed to analyze the variability in student perceptions.

The results showed that although half the students reported to be uninterested in equine nutrition, most expressed positive attitudes towards FC/PAL. Comparing the perceptions/views towards FC/PAL among low and high achievers, a significant difference was found for the item considering the duration of FC/PAL ($p=0.002$). Correlation analysis between questionnaire items showed a predominance of positive moderate correlations among high achievers and weak correlations among low achievers. PCA revealed three important findings. First, student interest towards equine nutrition explains the response variability among low achievers. Second, there was significant agreement among almost all high achievers regarding the duration of the FC/PAL. Third, in the item evaluating the usefulness of collaborating with peers, disagreement was only found among low achievers. In summary, a flipped classroom combined with the same level peer-assisted learning appears to encourage student interaction and collaboration in the classroom.

Keywords: teaching methods; flipped classroom; peer-assisted learning; low achievers; high achievers; veterinary students

1. Introduction

Competency in nutritional science is essential for veterinarians to be able to promote and maintain good health in all types of livestock [1], including horses [2]. Despite greater efforts being made to teach nutrition in veterinary curricula over recent years [3], veterinary education literature lacks research into the development of teaching methods to improve education in equine nutrition. Indeed, the literature has frequently highlighted the fact that the majority of graduated veterinarians lack knowledge and skills in this discipline [4,5]. One reason may be that insufficient teaching hours are being directed toward nutrition in veterinary schools, despite it being recognized as playing an essential role in animal health. It has a significant impact on the health [6], welfare [7], behavior [8], and performance of livestock [9]. In particular, the incidence of nutrition-related disorders is reported to be increasing in horses [10]. Due to the relevance of nutrition, it is important to develop innovative student-centered approaches such as flipped classroom (FC) and peer-assisted learning (PAL) to improve knowledge transfer. FC was first presented as a new teaching method in 2000, but has only recently been incorporated into veterinary curricula [11]. It requires students to acquire basic knowledge from activities performed outside the classroom, which may include online resources such as videos, other online material, tutorials, etc. [12,13]. PAL is another student-centered approach. It is described as “the acquisition of knowledge and skills by active helping and supporting among students” [14]. There are two predominant combinations of PAL: “near-peer PAL”, where senior students at a more advanced stage of their education teach more junior students, and “same-level PAL”, involving same-level students where the students are exposed to the new learning material together at the same stage of their education [15,16]. Same-level PAL is easier to organize since students are initially given the new material at the same time [15]. Recent research demonstrated that the implementation of PAL is an effective way to enhance the learning experience of students [17].

The integration of FC and PAL combines the advantages of both flipped learning and same-level peer assisted learning, providing a valuable tool to implement in teaching environments that have recently undergone disruption, for example, due the Covid-19 pandemic.

Evidence on how to structure an FC experience effectively is largely missing from equine education literature. Filling this gap is important to support veterinary science lecturers challenged with

finding the most effective ways to organize class activities. The aim of the present study was to establish a FC teaching format implementing PAL and to evaluate how suitable students perceived this teaching approach (FC with PAL) to be for teaching equine nutrition.

2. Material and Methods

2.1. Study Design and Population

The study participants were fourth-year veterinary science students (total number=92) studying in the Department of Veterinary Science at the University of Turin (Italy) in the academic year 2021-2022. All students were asked to complete a survey after completing the equine nutrition course delivered in a FC/PAL format.

After consulting with the ethical committee of the University of Turin, ethics approval was not deemed to be necessary due to the fact that the evaluation was conducted in an anonymously.

2.2. Course design

The equine nutrition course followed a blended learning approach, combining face-to-face teaching with FC/PAL. The FC/PAL design promotes student-centric active learning, which encourages higher cognitive learning processes, problem-solving competence, critical thinking, and engagement with the course content [13,15,18].

Due to the pandemic situation, the face-to-face teaching sessions were given remotely and were held once a week during the study period, which ran for a total of ten weeks. In the face-to-face teaching sessions, the teacher explained how the course was to be run and taught the subject matter for the different modules, set exercises, and discussed the students' results for each module of the FC/PAL activities (performed remotely due to the COVID). This more traditional setting was used to teach the participants the material they were required to learn and apply in the subsequent FC/PAL modules. The lecturer facilitated the group discussions and problem-solving exercises by orienting students toward the concepts which had been taught.

2.2.1. Flipped classroom (FC)

FC modules were subsequently run to facilitate further learning and put the knowledge acquired into the practice. The material taught in this way included up-to-date scientific literature and was divided into a total of six modules (see Figure 1) covering the following topics:

1. Horse digestive physiology:

- a. Anatomy of the equine digestive tract [19].
 - b. The physiological and behavioral needs of the horse [20,21].
2. Body condition score (BCS) and morphometric measurements in horses:
 - a. BCS scoring system according to the Henneke scale [22].
 - b. Cresty neck score according to Carter et al., 2008 [23].
 - c. Body weight (BW) estimation [24].
3. Horse feeds:
 - a. Forages type and quality; focus on forage needs according to Harris et al., 2016 [25,26]
 - b. Cereals, and other feeds commonly used in equine nutrition with a focus on carbohydrate analysis and starch content [27,28].
 - c. Feed label interpretation.
4. Horse nutritional requirements:
 - a. Energy, protein, mineral, and vitamin requirements for maintenance according to INRA (National Institute of Agricultural Research).
 - b. Requirement tables according to the physiological status of the horse [29].
5. Ration formulation and evaluation:
 - a. Use of a specific diet calculator for horses [30].
 - b. The formulation of maintenance diets for horses.
6. Diet planning for real cases:
 - a. Consideration of all the dietary requirements and the physiological and behavioral needs of the horse in order to prepare balanced diets [26,31].

Equine Nutrition

1. Horse Digestive Physiology:

- a. Anatomy of the equine digestive tract
- b. The physiological and behavioral needs of the horse



2. Body condition score (BCS) and morphometric measurements in horses:

- a. BCS scoring system
- b. Cresty Neck score
- c. Body weight (BW) estimation



3. Horse feeds:

- a. Forages type and quality; focus on forage need
- b. Cereals, and other feeds commonly used in equine nutrition with a focus on carbohydrate analysis and starch content
- c. Feed label interpretation



4. Horse nutritional requirements:

- a. Energy, protein, mineral, and vitamin requirements for maintenance
- b. Requirement tables



5. Ration formulation and evaluation:

- a. Use a specific diet calculator for horse
- b. The formulation of maintenance diets for horses



6. Diet planning for real cases:

- a. Consideration of all the dietary requirements and the physiological and behavioral needs of the horse in order to prepare balanced diets

Figure 1. Equine Nutrition Course Organization

At the end of each module student groups were required to complete specific tasks related to the content taught [32], comprising completing a quiz and calculating feed formulations or solving a case problem.

2.2.2. Peer-Assisted Learning (PAL)

Students were enrolled on the course in groups consisting of a maximum of 10 students. When attending the course, they were asked to divide in two smaller groups to facilitate social interaction and learning. Each group delegated one student to be in charge of coordinating the group's discussion and each module's task. The delegate was required to lead the work group, answer their peers' questions, and solve the required task.

2.3. Delivery of the course

Due to the Covid-19 pandemic the class for each module was delivered using an on-line video conferencing platform. The course involved one on-line four-hour lesson a week for a total of ten weeks. Students enrolled onto the course on a voluntary basis according to their study schedule.

At the start of each class, the tutor opened the session by explaining its organization and objectives, ensuring that each student had the necessary information to complete the module. Thereafter, a short introduction about the module's content was made and the students were divided into two groups which split off into two separate web rooms. Each group session had to be completed within a specified time frame with a mean duration of 1.5 hours, at the end of which the two groups rejoined initial virtual web class.

For each module a different team leader was selected by the group members to facilitate the team's work and complete the preparatory work outside of the virtual web class. The groups consulted the study material and the leaders were required to stimulate debate in the group and complete a given task. At the end of the time frame set for each module all students returned to the virtual web class with the tutor for an active discussion and gave their solution to the set task. The task required that the students revisit the module's material, in order to gain a better understanding of the subject, or to ask the tutor for further clarification.

2.4. Questionnaire Design

The questionnaire was developed to collect the students' views about the new teaching method used. Students were asked to answer n=9 score-based questions (Q) which gathered information on their level of interest in equine nutrition, how satisfied they were with the course, views on the usefulness of the course material, the course's organization, as well as other opinions about their experience. A 5-point Likert scale (1 - 2 = "strongly disagree or disagree", 3 = "neither disagree nor agree" and 4 - 5 = "strongly agree or agree") was chosen to evaluate each item [33].

At the end of the questionnaire two short-answer written questions required students to offer suggestions about how they thought the course and the proposed teaching method could be improved. Students were also asked to fill in a specific section with general information and background data (age, gender, and average exam score to date).

2.5. Data collection

The questionnaire was published online using google forms, and course participants completed the questionnaire on a voluntarily and anonymous basis. For this reason, no informed consent to participate in the study was obtained. All data collected remained absolutely anonymous, and it was impossible to trace the identity of the respondents. In addition, the questionnaires were blinded prior to statistical analysis, which was performed on a database containing the summarized data.

2.6. Data and Statistical Analysis

Following data collection, the responses of the questionnaire were coded and entered into a customized database (Excel 2019) before the statistical analysis.

The statistical program JMP pro 16, SAS, was used for the analysis. Summary statistics of the sampled population – response rate, gender, mean age of the students, average exam score – are reported as means and standard deviations (SD) or percentages (%). The low and high achievers among the students were determined using the students' average exam scores. Low achievers (L) were defined as having an average score of 20 to 25, while high achievers (H) were defined as having an average score of exams 26 to 30 [34].

2.6.1. Overall perception of students towards FC/PAL and comparison between low achievers and high achievers

The overall perception of students toward FC/PAL was described using a summary statistic of the students' responses to the questionnaire items. Moreover, the frequencies (%) of answers between low achievers and high achievers were analyzed using the chi square test. P-values < 0.05 indicate significant differences between the analyzed groups (L vs H).

2.6.2. Correlation between students' responses to questionnaire items and principal component analysis (PCA)

Bivariate analysis was used to investigate the students' perceptions/views of the FC/PAL method for teaching equine nutrition. Relationships between students' responses to the questionnaire items were analyzed using the Pearson's correlation coefficient (r , 1 or -1 depending on whether the variables are positively or negatively related). The r coefficient values for correlations were interpreted according to Raspa et al.2020 [6]: very strong correlation (± 0.91 to ± 1.00); strong correlation (± 0.68 to ± 0.90); moderate correlation (± 0.36 to ± 0.67); weak correlation (± 0.21 to ± 0.35); and negligible correlation (0 to ± 0.20). The probability of correlation (p-value) was calculated and Pearson correlations were considered significant for $p \leq 0.05$.

Moreover, principal component analysis (PCA, correlation matrix) was used to reduce the variables to factors. Data assumption for multivariate normality was checked using Keiser-Meyer-Olkin (KMO) and Barlett's tests, which were performed to test the suitability of the data for structure detection.

3. Results

Seventy-one students responded to the online questionnaire, although only 68 students completed the entire questionnaire, producing a response rate of 95.77%. The majority of the respondents were female (76.05%). The mean age of the students was 24.16 years (SD= 2.236). The average exam score was 25.67 (SD=1.420). Just over half (51.47%) of the respondents was

classified as being a low-achiever, having an average score of their previous exams between 20 and 25.

3.1. Overall perceptions/views of the FC/PAL teaching method

Table 1 shows the questionnaire responses of the 68 students involved in the present study. Data are reported as both the actual number and percentage (%) of students responding to each item. Table 1 also reports the answers given by students on the basis of the average of their exams (L vs. H achievers).

Table 1. Student responses to questionnaire items

Questionnaire Items	Count (%) Achievers	1-Strongly Disagree	2-Disagree	3-Neither Agree or Disagree	4- Agree	5-Strongly Agree
Q1 Interest I am interested in equine nutrition	All students	10 (14.7%)	24 (35.29%)	16 (33.52%)	12 (17.64 %)	6 (8.88%)
	Low	2 (5.71%)	15 (42.86%)	10 (28.57%)	8 (22.86%)	0 (0%)
	High	8 (24.24%)	9 (27.27 %)	6 (18.18 %)	4 (12.12%)	6 (18.18%)
Q2 Satisfaction I am satisfied with this learning activity	All students	0 (0%)	8 (11.76%)	18 (26.47%)	28 (41.17%)	14 (20%)
	Low	0 (0%)	4 (11.43%)	10 (28.57%)	15 (42.86%)	6 (17.14%)
	High	0 (0%)	4 (12.12%)	8 (24.24%)	13 (39.39%)	8 (24.24%)
	All students	2 (2.94%)	8 (11.76%)	11 (16.17%)	25 (36.65%)	22 (32.35%)
Q3 Usefulness I believe that the online teaching material provided will be useful in the future	Low	1 (2.86%)	4 (11.43%)	7 (20%)	12 (34.29%)	11 (31.43%)
	High	1 (3.03%)	4 (12.12%)	4 (12.12%)	13 (39.39%)	11 (33.33%)
	All students	2 (2.941%)	18 (26.47%)	22 (32.35%)	13 (19.11%)	13 (19.11%)
Q4 Duration The duration of the “Equine Nutrition” course was appropriate	Low	1 (2.86%)	10 (28.57%)	17 (48.57%)	4 (11.43%)	3 (8.57%)
	High	1 (3.03%)	8 (24.24%)	5 (15.15%)	9 (27.27%)	10 (30.30%)
	All students	3 (4.41%)	12 (17.64%)	17 (25%)	23 (33.82%)	13 (19.11%)
Q5 Remote mode The online mode is useful and appropriate for this activity	Low	2 (5.71%)	6 (17.14%)	8 (22.86%)	14 (40.00%)	5 (14.29%)
	High	2 (5.71%)	6 (17.14%)	8 (22.86%)	14 (40%)	5 (14.29%)
Q6 Interaction The new method of teaching the “Equine Nutrition” course was interactive	All students	1 (1.47%)	1 (1.47%)	9 (13.23%)	26 (38.23%)	31 (45.58%)
	Low	0 (0%)	1 (2.86%)	4 (11.43%)	15 (42.86%)	15 (42.86%)

	High	1 (3.03%)	0 (0%)	5 (15.15%)	11 (33.33%)	16 (48.48%)
	All students	1 (1.47%)	2 (2.94%)	9 (13.23%)	22 (32.35%)	34 (50%)
Q7 Peer collaboration I believe that collaborating with peers is very beneficial and useful for the learning process	Low	0 (0%)	0 (0%)	6 (17.14%)	15 (42.86%)	14 (40%)
	High	1 (3.03%)	2 (6.06%)	3 (9.09%)	7 (21.21%)	20 (60.61%)
Q8 Participation The online session of “Equine Nutrition” allowed me to participate and interact more	All students	3 (4.41%)	17 (25%)	15 (22.05%)	18 (26.47%)	15 (22.05%)
	Low	0 (0%)	9 (25.71%)	7 (20 %)	11 (31.43%)	8 (22.86%)
	High	3 (9.09%)	8 (24.24%)	8 (24.24%)	7 (21.21%)	7 (21.21%)
	All students	1 (1.47%)	6 (8.82%)	17 (25%)	28 (41.17%)	16 (23.52%)
Q9 Course organization The “Equine Nutrition” course is well-defined and structured	Low	0 (0%)	4 (11.43%)	8 (22.86%)	15 (42.86%)	8 (22.86%)
	High	1 (3.03%)	2 (6.06%)	9 (27.27%)	13 (39.39%)	8 (24.24%)

Considering the responses of both the low achievers and high achievers (Table 2), exactly half of the students (50%) reported to be uninterested in equine nutrition. Only 26.47% of the students were positively interested in equine nutrition (Q1). Despite half of the students being uninterested in equine nutrition, 61.76% indicated that they were satisfied with the FC/PAL learning activities carried out, and surprisingly only 11.76% of the students reported not to be satisfied with the FC/PAL activity (Q2). Moreover, 69.11% of the students expected that the educational material provided to them would be useful in the future, whereas only a minority (14.71 %) thought that the material would not be of any use (Q3). With respect to the course duration, a number of different perceptions were obtained. Just over half (52.94%) of the students considered the duration of the course to be appropriate, while 29.41% thought differently (Q4). Nearly, 52.94% of the students agreed or strongly agreed with the statement that the online modality was appropriate for carrying out the FC/PAL activity, whereas 22.05% strongly disagreed or disagreed with that statement (Q5).

The majority of students considered the FC/PAL to be interactive. Specifically, 83.82% agreed or strongly agreed with the statement, while only 2.94% of them disagreed or strongly disagreed (Q6). Moreover, the large majority of students (82.35 %) strongly agreed or agreed with the statement that collaborating with their peers was beneficial for their learning, while only a few of them (4.41%) strongly disagreed or disagreed with the statement (Q7). Mixed perceptions were obtained regarding the allowance of participation in the FC/PAL format. While 48.53% of the

students strongly agreed or agreed with the statement “The online session of Equine Nutrition allowed me to participate and interact more”, 29.41% of the students disagreed or strongly disagreed (Q8). The majority of students (64.70%) judged the FC/PAL course to be well-defined and structured, although 10.29% did not agree with that statement (Q9).

Table 2. Comparison between low (L) and high (H) achievers in levels of disagreement and agreement.

	Strongly Disagree and Disagree (1-2)	Agree and Strongly Agree (4-5)
Q1. I am interested in equine nutrition	50% (L50% vs H50%) <i>p-value</i> = 0.80	26.47% (L44.4% vs H55.5%) <i>p-value</i> = 0.49
Q2. I am satisfied with this learning activity	11.76% (L50% vs H50%) <i>p-value</i> = 0.93	61.76% (L50% vs H50%) <i>p-value</i> = 0.76
Q3. I believe that the online teaching material provided will be useful in the future	14.71% (L50% vs H50%) <i>p-value</i> = 0.92	69.11% (L48.94% vs H51.16%) <i>p-value</i> = 0.53
Q4. The duration of the “Equine Nutrition” course was appropriate	29.41% (L55% vs H45%) <i>p-value</i> = 0.71	52.94% (L26.9% vs H73.1%) <i>p-value</i> = 0.002
Q5. The online mode is useful and appropriate for this activity	22.05% (L53.3% vs H46.7%) <i>p-value</i> = 0.87	52.94% (L52.7% vs H47.3%) <i>p-value</i> = 0.82
Q6. The new method of teaching the “Equine Nutrition” course was interactive	2.94% (L50% vs H50%) <i>p-value</i> = 0.90	83.82% (L52.6% vs H47.4%) <i>p-value</i> = 0.66
Q7. I believe that collaborating with peers is very beneficial and useful for the learning process	4.41% (L0% vs H100%) <i>p-value</i> = n/a	82.35% (L51.8% vs H48.2%) <i>p-value</i> = 0.91
Q8. The online session of “Equine Nutrition” allowed me to participate and interact more	29.41% (L45.5% vs H55.5%) <i>p-value</i> = 0.49	48.53% (L57.6% vs H42.4%) <i>p-value</i> = 0.33

Q9. The “Equine Nutrition” course is well-defined and structured	10.29% (L57.1% vs H42.9%) <i>p-value</i> = 0.75	64.70% (L52.3% vs H47.7%) <i>p-value</i> = 0.86
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Note. The percentages of respondents who chose a neutral/undecided response (3 = “neither disagree nor agree”) were excluded from the final statistical analysis.

It is important to note that the percentages of respondents who chose a neutral/undecided response (3 = “neither disagree nor agree”) were excluded from the final statistics to aid the comparison of the level of agreement and disagreement between L versus H achievers. As shown in table 2, when comparing L and H achievers in terms of their different perceptions towards FC/PAL, a significant difference was obtained with regards to their views on the course’s duration (Q4). In particular, a significant difference was found for the score 4-5 (strongly agree and agree), with significantly more high achievers selecting this response compared with low achievers (73.1% vs 26.9%, respectively; $p=0.002$). No significant differences in views/perceptions were identified between low achievers and high achievers for any other items of the questionnaire.

3.2. Correlation between questionnaire items

The correlations between the questionnaire items (Q1-Q9) among low and high achieving students are shown in Figure 2. With respect to the overall correlations, there is a predominance of moderate positive correlations among high achievers and weak correlations among low achievers.

3.2.1. Low Achievers

Student interest in equine nutrition (Q1) was significantly correlated with responses to Q3 only ($r=0.42$, $p=0.01$) (the questionnaire item evaluating the perceived usefulness of the online material used in the FC/PAL), which in turn revealed a significant correlation with the item rating student satisfaction in the FC/PAL teaching method (Q2) ($r=0.45$, $p=0.006$) and the items evaluating peer interaction (Q6) ($r=0.37$, $p=0.02$) and the course’s definition and structure (Q9) FC/PAL ($r=0.45$, $p=0.005$).

In addition, student satisfaction towards the FC/PAL teaching method (Q2) was significantly correlated with the item (Q4), which evaluated the students’ views on the adequacy of the time provided to carry out the FC/PAL ($r=0.36$, $p=0.02$), Q6 ($r=0.41$, $p=0.01$) and Q9 ($r=0.45$, $p=0.01$). Moreover, Q2 revealed a significant positive correlation with questionnaire item (Q7), which evaluated students’ perceptions towards collaborations between peers ($r=0.45$, $p=0.04$). Item Q8,

which evaluated views on whether FC/PAL provided the opportunity for students to participate and interact more, was positively correlated with Q6 ($r=0.59$, $p=0.0002$) and Q5 ($r=0.41$, $p=0.013$) (the item evaluating the suitability of the online mode for carrying out FC/PAL activities), which was in turn positively correlated with Q6 ($r=0.44$, $p=0.006$).

Lastly, the most positive significant correlations were revealed between Q9 and Q2 ($r=0.56$, $p=0.0001$), Q3 ($r=0.45$, $p=0.006$), Q4 ($r=0.42$, $p=0.011$), Q5 ($r=0.54$, $p=0.0007$), Q6 ($r=0.56$, $p=0.004$), and Q7 ($r=0.33$, $p=0.048$).

3.2.2. High achievers

Among high achievers, student interest in equine nutrition (Q1) was significantly correlated with Q3 ($r=0.58$, $p=0.0004$), and Q9 ($r=0.36$, $p=0.037$). In addition, responses to Q2 were significantly correlated with the responses to Q3 ($r=0.67$, $p<0.0001$), Q5 ($r=0.34$, $p=0.052$), Q6 ($r=0.62$, $p<0.001$), and Q9 ($r=0.78$, $p<0.0001$). Moreover, responses to Q3 were significant correlated with those given to Q6 ($r=0.48$, $p=0.004$), Q8 ($r=0.35$, $p=0.049$), and Q9 ($r=0.78$, $p<0.0001$), while responses to Q4 were only significantly correlated with responses to Q7 ($r=0.45$, $p=0.009$). In addition, responses to Q5 were significantly correlated with responses to Q6 ($r=0.55$, $p=0.001$) and Q8 ($r=0.56$, $p=0.0008$), which in turn revealed a significant correlation between each other ($r=0.45$, $p=0.009$).

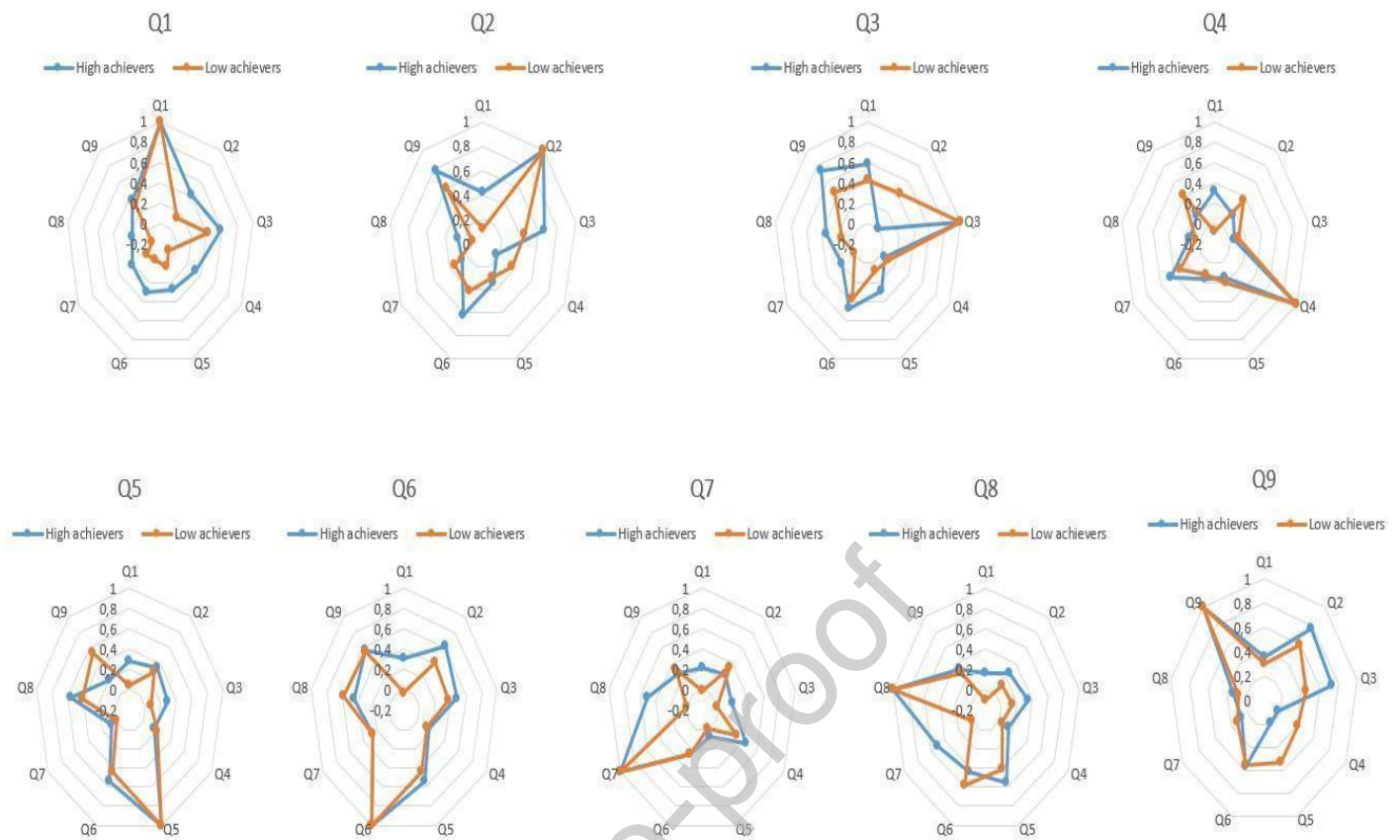


Figure 2. Correlation between questionnaire items among low and high achiever students.

3.3. Principal component analysis (PCA)

Principal component analysis (PCA) was performed to explain the variability in student's perceptions/views and attitudes towards the FCA/PAL (see Figure 2).

A) Low achievers

B) High achievers

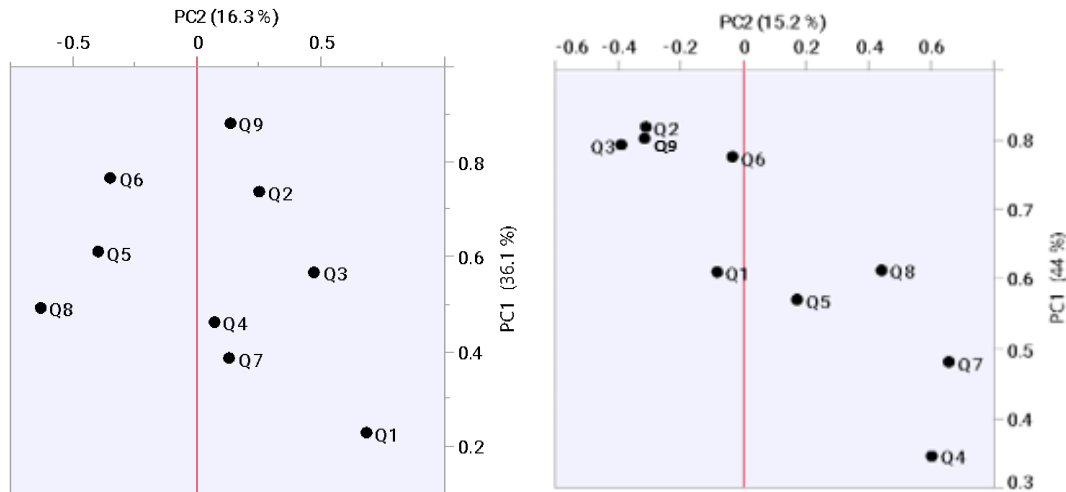


Figure 3. Principal component analysis biplot (PC1 and PC2) performed on the questionnaire item scores for students belonging to low achievers vs high achievers

The suitability of the data for PCA was evaluated ($KMO = 0.80$; Barlett's test, $p < 0.01$). Figure 3a refers to low achievers and shows that PCA separated the questionnaire items on the first principal component: component 1 (PC1) explains 36.1% of the variance of the data, and component 2 (PC2) another 16.3%, accounting for 52.5% of variability. In addition, Figure 3b which refers to high achievers students shows that PCA separated the questionnaire items on the first principal component: component 1 (PC1) explains 44% of the variance of the data, and component 2 (PC2) another 15.2%, accounting for 59.2% of variability. The questionnaire item that best describes the response variability among low achievers is Q1. This variability derives from the fact that none of the low achievers strongly agreed with Q1 (see table 1). On the other hand, considering the PCA of high achievers, the questionnaire items that best describe the variability of the responses are Q4 and Q7. In summary, the high achievers revealed a high positive response rate to Q4 and Q7; in other words, disagreement with the statement only occurred among the high achievers (4.41%).

4. Discussion

Considering the complex process of acquiring clinical competence in equine nutrition, we designed a flipped classroom (FC) teaching format combined with peer-assisted learning (PAL) focusing on equine nutrition concepts. Both strategies are relatively new in veterinary education, and to the best of the authors' knowledge this is the first study to assess these concepts in the field of equine nutrition education.

In the present study, half of the students (50%) reported to be uninterested in equine nutrition, in line with the reports by the European Associations of Establishments for Veterinary Education (EAEVE) and the fact that most veterinary schools in Europe report a shortage in veterinary graduates willing to launch their careers in animal nutrition [35]. Nevertheless, the innovative teaching method studied here was well received and appreciated by nearly two-thirds (61.76 %) of the students. Qualitative analysis of the open-ended questions suggested that, in general, students expressed positive impressions towards FC/PAL. Moreover, some suggestions were made about how to improve the learning material and about expanding the number of clinical cases provided in the teaching material. An interesting finding was that most of the students (69.11 %) confirmed to consider the on-line learning material helpful for their future work. There is no doubt that the integration of information and communication technologies (ICT) into teaching approaches has fundamentally changed how today's veterinary students learn new material [36]. Indeed, students generally tend to prefer digital material [37] which can be accessed at their own convenience. Moreover, a survey study addressing nutrition education in 63 European veterinary schools suggested the use of on-line learning materials as a potential solution to improve nutrition education across veterinary schools [4]. The questionnaire results show that the majority of the students were satisfied with the equine nutrition activities/tasks carried out (FC/PAL) and found it very interactive and well-defined.

FC/PAL shifts the learning process of transferring knowledge in equine nutrition to before the student-centered tasks are carried out, thereby allowing students to use the learning material according to their personal learning needs in an informal environment. The FC/PAL approach helps develop students' learning capacities, meet individual learning needs and interests, and promote self-directed learning, and these may be some of the reasons why the students of the present study reported to be generally satisfied with it [38–40]. Secondly, FC/PAL boosts student-teacher interactions, since the students come to the class already more familiar with the course material [18,41]. Another possible reason may be that FC/PAL generally allows personalized learning [41,42] and permits students with different learning preferences to manage their learning

according to their own specific learning style. Conversely, in the traditional classroom, the teacher pays attention to the needs and interests of the majority of the students and cannot customize the teaching to each student's needs.

A notable aspect was that same-level PAL was indicated as preferred by the vast majority of the students, nearly 83%. A possible reason explaining this finding can be that during PAL, students are less fearful of making errors in front of their peers rather than in front of teachers [17,43], thereby feeling more satisfied with the learning experience. Since the same learning goals are shared in this collaborative environment and students have the same academic background, the students may be subject to less stress, which may in turn facilitate the learning process [17] and help build student self-confidence.

When comparing the perceptions and attitudes towards FC/PAL among low and high achievers no substantial significant differences were found. More specifically, only the item evaluating the appropriate duration of the FC/PAL demonstrated significant differences ($p=0.002$). Interestingly, the majority of respondents who expressed that they "strongly agree" or "agree" that the duration of the FC/PAL was appropriate were high achieving students (73.1 %). This finding can be explained by the fact that, in general, high achievers fully participate in learning activities [44]. It is plausible to think that engaged students who accomplish specific goals and achieve a desirable result will be more satisfied with the duration of the course since their goals are met.

The correlation analysis between questionnaire items showed a predominance of positive moderate correlations and even strong correlations among the high achievers. In the same vein, Ahmed and colleagues in 2018 concluded in their study that the perceptions of high achieving students towards the learning environment were significantly better than those of low achievers [45].

In addition, the correlation analysis between questionnaire items further demonstrated a predominance of weak correlations among low achieving students. However, no substantial significant differences were found among two groups of students.

We made three important findings using principal component analysis to explain the variability in student's perceptions and attitudes towards the FC/PAL activities. First, the students' interest in equine nutrition best describes the response variability among the low achievers. More specifically, none of the low achievers indicated to strongly agree with the questionnaire item (Q1-interest). Outside veterinary education, several studies have demonstrated that low achieving

students generally show less interests towards learning disciplines [45–47]. Secondly, in the questionnaire item evaluating the appropriate duration of the FC/PAL (Q4-duration), a total of 19 high achievers out of 33 (57%) agreed and strongly agreed with the item; in other words, the majority of high achievers found the duration appropriate. As discussed above, since high achievers are more likely to participate fully in the learning activities, they are also more likely to find the duration appropriate. Lastly, in the item evaluating the utility of collaborating with peers (Q7-peer collaboration), disagreement was only found among low achievers. It is plausible to think that high achievers tend to be more confident as well as independent; thus, they can learn and perform the learning activities and tasks by themselves. However, it is worth mentioning that a few high achievers also disagreed with the statement (4.41%), therefore, this result cannot be generalized.

Moreover, our study has some limitations. First, the study did not contain a control group, and, second, our study did not investigate the effectiveness of the FC/PAL approach in terms of student outcomes based on quantitative independent measures such as exam performance. However, despite the above-mentioned limitations, the present research sheds light on the positive attitudes and perceptions of students towards new teaching and learning approaches that boost their satisfaction and interaction.

We would recommend future research to study the effectiveness of FC/PAL in equine nutrition courses by addressing these limitations. In particular, future studies should explore the extent to which the actual performance of students may or may not be affected by the FC/PAL, thus, moving beyond student perceptions.

5. Conclusions

The present study focused on the use of modern pedagogical approaches to teach equine nutrition in veterinary sciences. Our data demonstrated that the majority of the students were satisfied with the FC/PAL activity carried out. Most of the students considered the learning material provided to be useful for their future work. Moreover, the collaborative nature of the work among peers was highly appreciated by the students. No significant differences were found between low versus high achievers; however, high achievers tended to express more positive views and attitudes towards FC/PAL.

To conclude, we observed that a flipped classroom combined with the same level peer-assisted learning approach (FC/PAL) is helpful for student collaboration and interaction in the classroom.

An innovative approach to teaching equine nutrition could help develop interest in the discipline as well as the necessary skills that are currently under-represented in the workplace.

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Declarations

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

E. Muca contributed to study design, data collection, data management, data analysis and preparation of the manuscript. D. Cavallini: contributed to data management, data analysis and preparation of the manuscript. F. Raspa: contributed to questionnaire design, data analysis support and preparation of the manuscript. C. Bordin: made data analysis support and preparation of the manuscript. D. Bergero: was involved in study design, coordination and study execution. E. Valle: contributed to questionnaire and study design, coordination and preparation of the manuscript. All authors have read, edited and approved the final manuscript.

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Ethical Statement

After consulting with the ethical committee of the University of Turin, ethics approval was not deemed to be necessary due to the fact that the evaluation was conducted in an anonymously. It is important to highlight that the provisions that we have followed are in accordance with the Italian legislation. More specifically, since there was no medical treatment or other procedures that could cause psychological or social discomfort to participants, additional ethical approval was not required. The research was conducted in line with the Helsinki Declaration, as well as the data protection regulation of Italy (Legislative Decree No. 196/2003). Participation in the research was voluntary, without receiving any reward. In addition, the questionnaires were blinded prior to statistical analysis, which was performed independently by a specialist on a database containing summarized data.

Declaration of interest:

None