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Original article

Animal use in pharmacy undergraduate pharmacology laboratories: Students' perceptions and need assessments

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ABSTRACT

Background: During the undergraduate years, laboratory practical classes using experimental animals are important in pharmacy schools. Limitations for experimental use of animals exist, including the procurement of animals, the difficulty in performing animal experiments, ethical considerations, and more often students' preferences.

Objective: To evaluate pharmacy students' perceptions, barriers, and confidence regarding animal use in the pharmacology laboratory course, and the effect of animal handling on their confidence.

Methods: This observational pre- and post-course parallel group design study was conducted during the Pharmacology laboratory involving 3rd-year pharmacology students from one school of pharmacy in Jordan. A questionnaire was designed and validated to collect students' demographic characteristics, perceived barriers and perceptions regarding animal handling during the lab, and the level of confidence pre- and post-course, assessing differences between those who handled and those who did not handle animals.

Results: All Pharmacology lab students (n = 212) with a mean age of 21.11 (SD 1.32) and the majority being females (77.0%) were enrolled. Students who refused to handle animals (n = 105, 49.5%) stated phobia as the main barrier. Students who accepted to handle animals agreed more with the importance of seeing and practicing animal handling, with animal handling being essential to understand the effect of drugs on animals and in its importance to gain skills, than those who refused. More than half of students (55.9%) reported feeling confident/somewhat confident in animal handling and in giving animals injections (50.8%) at baseline. At the end of the course, students who accepted animal handling reported significantly higher confidence.

Conclusion: This study revealed important students' barriers and perspectives to animal handling. Those who handled the animals reported better confidence in certain areas at the end of the course than those who refused. Engaging students when making decisions regarding educational practices paves the way for change to the current traditional paradigm in the education of future scholars.

1. Introduction

Over the years, animals, such as mice, rats, guinea pigs and rabbits, have been used in tertiary educational institutions to provide students with the skills needed to perform certain activities (Wheeler, 1993). Use of animals has also been a central part of research development in postgraduate university education. Most of the current drug discoveries were made possible because of the use of animals in research (Badyal and Desai, 2014). It is well acknowledged that clinical research conducted by the pharmacy and medical field students require *in vivo* skills; the actual handling and treating of animals, in addition to experimental design and statistical analysis.

During the undergraduate years, laboratory practical classes using experimental animals are important in several health-science courses (Badyal et al., 2009; Ranganatha, 2012; Dewhurst, 2007). Moreover, the study of human diseases often involves performing lab-based physiological and pharmacological experiments on animal models. Engaging students in simple

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research-like activities, including animal handling, not only advance their research skills but also helps them to gain the required *in vivo* skills (King et al., 2011).

Limitations for experimental use of animals exist, including the procurement of animals, the difficulty in performing animal experiments, strict regulations, ethical considerations, and more often students' preferences (Tansey, 1998). That is why, nowadays, animal use is being replaced by other alternative methods, and new technologies such as computer simulations (Dewhurst, 2004). This change was further driven by responsible authorities, like the European Union, regarding the protection of animal use for experimental and other scientific purposes (Hendriksen, 1994). This change was also supported at times by internal independent policies of different organizations and universities.

At the university teaching level, students' preferences play a significant role in the education they receive, and involvement in animal handling and experimenting on animals is not an exception. In Jordan, the majority of animals used for undergraduate education are for laboratory practical classes (wet labs) in Pharmacology and Physiology. This is similar to other countries around the world (Dewhurst, 2004). In higher education, the role of animals in teaching and training has been for long questioned, due to its contentious nature.

At Applied Science Private University (ASU), Amman, Jordan, Pharmacology laboratory is a unit of study delivered in the 3rd year of the Bachelor of Pharmacy curriculum (5-year degree program). The key focus is to enable students to acquire knowledge regarding the pharmacology of common medical conditions. As a part of the objectives of this course unit, students practice injecting experimental animals (mainly mice) with different drugs, then observing and reporting the effects they have seen on these animals. In some experiments, the animals die (e.g. deep irreversible sedation with propofol, hypoglycemia with insulin, and respiratory depression (more rarely) with morphine). Over the years, students have shown preference toward shifting away from animal handling. Simultaneously, many students refused to perform the actual experiments on animals, and more specifically, experiments that led to their death in most cases. Reasons behind such preference were not distinctive, ranging from the animal-handling phobia, lack of self-confidence in handling animals, to certain ethical and religious beliefs. No previous study has explored profoundly pharmacy students' perceptions regarding animal handling in the Pharmacology laboratory course units in the Western or Eastern higher educational institutes.

The aim of this study was to assess pharmacy students' perceptions regarding animal use in the Pharmacology laboratory course unit, their confidence in animal handling pre- and -post-course, and their gained skills in this area, hence evaluating the need for animal use in the Pharmacology laboratory.

2. Methods

2.1. Design

This was an observational pre- and post-course parallel group design study approved by the Applied Science Private University Ethics Committee (ethics approval no. 11/2014/2015). It was conducted in the Pharmacology laboratory during 2014. The study included all students enrolled in these classes in the 3rd year of ASU Bachelor of Pharmacy curriculum.

Within this unit of study, students were divided into 4 lab classes (the classes were a replicate of each other). Each student attended one Pharmacology laboratory class per week for 10 weeks. Over this 10-week period, each lab was facilitated by one tutor (with a Bachelor in Pharmacy degree) and one lecturer (Ph.D. or Master's degree holder in Pharmacology or Clinical Pharmacy) and lasted for 3 h. Laboratories were spread throughout the week and included animal handling experiments, as well as appropriate hands-on and small-group activities. Students were evaluated through an end-of-semester practical assessment, multiple-choice and written examinations, and throughout-semester tutorial participation.

2.2. Baseline assessment

In the 2nd week of the semester, students were informed of the nature of the study and informed consents were provided. Students were given the choice between handling animals when needed in the laboratory experiments (group A) and not to handle animals, but only to observe their handling by their supervisor during the experiments (group B). At this stage, all participants were shown (at the beginning of the second-week laboratory) how the animal handling is performed before making their decision.

All students completed the baseline questionnaire assessing reasons for refusing animal handling at baseline, perceptions regarding the Pharmacology laboratory and animal handling at baseline and students' level of confidence in handling animals. At the end of the study, perceptions regarding the Pharmacology laboratory and animal handling, and level of confidence in handling animals were reassessed comparing students who accepted to handle animals to those who refused.

2.3. Study tools

A questionnaire was designed to collect data regarding students' baseline demographic characteristics (Part A), perceptions regarding the Pharmacology laboratory and animal handling (Part B), and students' level of confidence in handling animals (Part C).

Part A was designed to collect data including age, gender, nationality, years of study (3 years being the expected period, and more for delayed students, or students who have failed previously).

Part B consisted of 10 items using a Likert scale to measure the level of agreement with each item, ranging from '1' referring to 'strongly disagree' to '5' referring to 'strongly agree'. The proportion of respondents who agreed and disagreed with each item was evaluated, with a Likert scale measuring the level of agreement 'strongly agree', 'agree', 'neutral' 'disagree', 'strongly disagree' (scale out of 5 points). A final question was provided to the students who refused to handle the animals, investigating the reason/s behind their refusal, with 9 options provided (more than one option could be chosen by the students).

Part C involved three questions investigating students' confidence with regards to animal handling, giving injections to animals and performing all of the different parts/ activities included in the lab.

English is the official language of education for all healthcare professionals in Jordan; hence the questionnaire was administered in English (online Appendix 1).

2.4. Questionnaire validation

The developed questionnaire underwent content validity assessment where it was studied carefully by the two authors to ensure that all the content assessed animal handling perceptions by the students. Face validity was completed by allowing 15 of the 3rd year students (pharmacy students who are not yet attending this Pharmacology laboratory course) to provide a report containing comments about the questionnaire contents, wording, simplicity and what can be done to improve the questionnaire. Every comment was studied by the authors, and where

appropriate, necessary steps were taken to improve the questionnaire. The questionnaire was then evaluated by 3 clinical pharmacists (academics and researchers in clinical pharmacy). Views and comments of the researchers were considered and then incorporated where appropriate into the final version of the questionnaire.

To assess test-retest reliability, the questionnaire was administered on two occasions to 15 randomly selected pharmacy students who completed the Pharmacology lab previously (the computer-generated randomization program was used (www.randomizer.org). The second testing took place two weeks after the first one. This set of data was not included in the final analysis. Test-retest reliability was calculated using Spearman's correlation coefficient (r). A rho-value of (0.89) implied acceptable test-retest reliability.

2.5. Focus group interview

An open invitation was extended to 10 students from both groups, randomly selected by the researchers, to attend a Focus Group session to elicit comments about their perception about animal handling. A series of open-ended questions were prepared as a basis for the semi-structured interview format, and the session was facilitated by the researchers. The questions were:

1. To what extent did animal handling in the Pharmacology laboratory help you to gain the skills and knowledge needed?
2. How did you feel about animal handling?
3. Was the training on animal handling in the laboratory sufficient for your own practice?
4. How would you make use of the skills learned in the Pharmacology laboratory in your future career?
5. Do you think that animal handling during the Pharmacology laboratory could be removed from its content in the future?
6. Could simulation replace animal handling in the Pharmacology laboratory?

2.6. Data analysis

The data from each of the returned questionnaires were coded and entered into the Statistical Package for the Social Sciences (SPSS, version 21, Chicago, IL, USA) software which was used for statistical analysis. The mean ± standard deviation values and the 95% confidence interval (CI) were used to describe the normally distributed continuous data (normality of distribution was determined using the Kolmogorov-Smirnov test). Proportional data were analyzed using Pearson's Chi-Square test (or Fisher's exact test). Pre- and post-course questionnaire scores were compared using Wilcoxon signed rank test. For all statistical analysis, p-values of 0.05 or less were considered statistically significant.

Data from the recording of the Focus Group conversations were analyzed thematically.

3. Results

3.1. Students' demographics

All Pharmacology laboratory students (n = 212) were enrolled in the study. The students attended one of four different classes (3 h each) during the week, with each class supervised by a different teaching assistant (credited pharmacist). Mean age of students was 21.11 (SD 1.32; ranging from 20 to 29 years) with the majority being females (76.9%) and in their third year of study (92.0%). Students came from different backgrounds, with the majority being from Jordan (55.2%) or Iraq (28.3%).

3.2. Barriers to animal handling

Students who refused to handle the animals (n = 105) gave reasons/barriers for their refusal (Fig. 1). Majority of them reported phobia, refusing to work with animals that are not certified to be clean or pathogen-free, because of no enough practice to handle animals and because of their belief that there is no need for such skills for their future pharmacy career. Few students reported other reasons including 'it's not a humanitarian behavior' (n = 1/105) and that it is repulsive (n = 2/105).

3.3. Students' perceptions regarding animal handling

Majority of student agreed/strongly agreed with the importance to see animal handling (83.0%) and to practice animal handling in

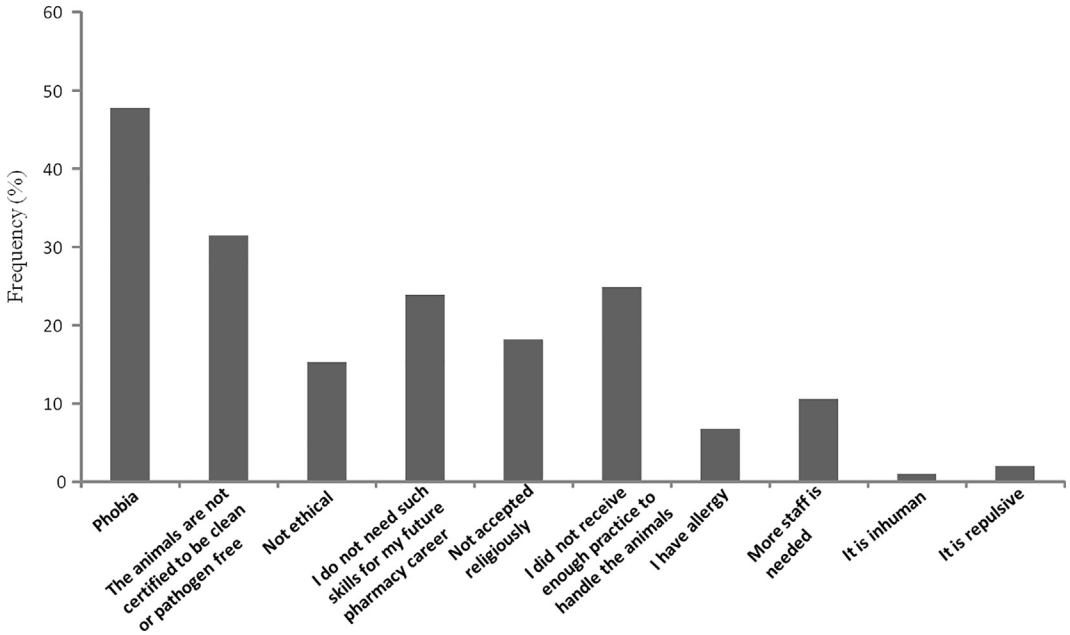

Fig. 1. Reported barriers for refusing animal handling by students who refused to handle the animals in the Pharmacology lab (n = 105).

Table 1
Students' perceptions (n = 212) regarding Pharmacology laboratory and animal use.

Item	SD	D	N	A	SA
It is important to see animal handling in the practical Pharmacology labs	9/214 (4.20)	8/211 (3.80)	19/211 (9.00)	85/212 (40.10)	91/212 (42.90)
It is important to practice animal handling in the practical Pharmacology labs	19/209 (9.10)	20/211 (9.50)	32/211 (15.20)	72/210 (34.30)	67/210 (31.90)
Animal handling in the Pharmacology lab is essential to understand the effect of drugs	16/213 (7.50)	18/212 (8.50)	25/212 (11.80)	83/212 (39.20)	70/212 (33.00)
Important skills in the practical Pharmacology lab can only be gained through animal handling	15/208 (7.20)	30/210 (14.30)	48/209 (23.00)	82/209 (39.20)	34/209 (16.30)
There are no alternatives for animal handling in the practical Pharmacology labs	17/207 (8.20)	38/208 (18.30)	50/208 (24.00)	75/208 (36.00)	28/207 (13.50)
The benefits gained from testing drugs on animals in the lab makes it ethical	14/211 (6.60)	33/211 (15.60)	47/211 (22.30)	72/211 (34.12)	45/211 (21.30)
I like handling animals (mice) in the Pharmacology lab	44/210 (21.00)	45/210 (21.40)	53/210 (25.20)	31/209 (14.80)	37/210 (17.60)
If not required, I prefer not to handle animals in the labs	23/209 (11.00)	36/211 (17.10)	47/210 (22.40)	55/210 (26.20)	49/210 (23.30)
I like handling other animals in the Pharmacology labs (e.g. rats/rabbits)	66/207 (31.89)	56/207 (27.05)	35/207 (16.91)	26/207 (12.56)	24/207 (11.59)
I have important beliefs and reasons for refusing to handle animals in the lab	37/208 (17.80)	51/208 (24.50)	51/208 (24.50)	44/208 (21.20)	25/208 (12.00)

SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree.

the practical Pharmacology laboratory (66.2%). About half of the students (55.5%) agreed/ strongly agreed that important skills in the practical Pharmacology class can only be gained through animal handling, that there are no alternatives for animal handling (49.5%) and that the benefits gained from testing drugs on animals in the laboratory makes it ethical (55.4%). Only 32.4% stated that they liked handling animals (mice) during the Pharmacology laboratory (24.2% for other animals), and about half of the students would prefer not to handle animals in the laboratory if it was not required. Many students (33.2%) reported to having important beliefs and reasons for refusing to handle animals in the lab (Table 1).

Students who accepted to handle animals reported a significant difference in almost all of the perceptions and preferences questions compared to those who refused to handle animals (Table 2). They agreed more with the importance of seeing and practicing animal handling, that animal handling is essential to understand the effect of drugs on animals and in its importance to gain skills, they believe that there are no other alternatives to animal handling, and reported that they like to handle animals even if not required.

3.4. Student confidence

Regarding students' confidence, more than half of students who accepted to handle animals reported feeling confident/ somewhat confident in handling animals (55.9%) and in giving animals injections during the laboratory (50.8%). Only 56.7% of students reported feeling confident/ somewhat confident to do all parts/ activities involved in the Pharmacology lab (Table 3). No significant difference at baseline with regards to student confidence was reported between those who accepted animal handling and those who refused.

At the end of the course, 152 students (76.3% females) randomly completed the 'confidence' questionnaire. The overall students' confidence in giving injections to perform the experiments

Table 2
Students' perceptions regarding Pharmacology laboratory and animal use for students who 'Refused' and students who 'Accepted' animal handling at baseline and end of the study.

Item	Accepted (n = 107)					Refused (n = 105)					P value
	SD	D	N	A	SA	SD	D	N	A	SA	
It is important to see animal handling in the practical Pharmacology labs	1/108 (0.93)	2/107 (1.87)	7/107 (6.54)	39/107 (36.45)	58/107 (54.21)	8/105 (7.62)	6/105 (5.71)	12/105 (11.43)	46/105 (43.81)	33/105 (31.43)	**0.003**
It is important to practice animal handling in the practical Pharmacology labs	1/108 (0.93)	4/107 (3.74)	12/108 (11.21)	45/107 (42.06)	45/107 (42.06)	18/103 (17.48)	16/103 (15.53)	20/103 (19.42)	27/103 (26.21)	22/103 (21.36)	**<0.001**
Animal handling in the Pharmacology lab is essential to understand the effect of drugs	1/108 (0.93)	8/107 (7.48)	9/107 (8.41)	40/107 (37.38)	49/107 (45.79)	15/105 (14.29)	1/105 (9.52)	16/105 (15.24)	43/105 (40.95)	21/105 (20.00)	**<0.001**
Important skills in the practical Pharmacology lab can only be gained through animal handling	3/105 (2.86)	10/105 (9.52)	20/105 (19.05)	42/105 (40.00)	30/105 (28.57)	12/104 (11.54)	20/104 (19.23)	28/104 (26.92)	40/104 (38.46)	4 /104 (3.85)	**<0.001**
There are no alternatives for animal handling in the practical Pharmacology labs	7/105 (6.67)	12/126 (9.52)	30/105 (28.57)	32/105 (30.48)	24/105 (22.86)	10/16 (63.60)	26/38 (69.20)	20/42 (47.40)	43/73 (59.00)	4/18 (22.60)	**<0.001**
The benefits gained from testing drugs on animals in the lab makes it ethical	3/107 (2.80)	10/107 (9.35)	20/214 (9.35)	39/107 (36.45)	35/107 (32.71)	11/14 (78.80)	23/32 (72.20)	27/44 (61.50)	33/70 (47.30)	10/35 (28.60)	**<0.001**
I like handling animals (mice) in the Pharmacology lab	7/123 (5.71)	18/105 (17.14)	30/105 (28.57)	24/105 (22.86)	27/105 (25.71)	38/105 (36.19)	27/105 (25.71)	23/105 (21.90)	7/105 (6.67)	10/105 (9.52)	**<0.001**
If not required, I prefer not to handle animals in the labs	13/105 (12.38)	22/105 (20.95)	30/105 (28.57)	27/105 (25.71)	13/105 (12.38)	10/105 (9.52)	14/105 (13.33)	17/105 (16.19)	28/105 (26.67)	36/105 (34.29)	**0.002**
I like handling other animals in the Pharmacology labs (e.g. rats/rabbits)	30/103 (29.13)	22/103 (21.36)	19/103 (18.45)	17/103 (16.5)	15/103 (14.56)	36/104 (34.62)	34/104 (32.69)	16/104 (15.38)	9/104 (8.65)	9/104 (8.65)	0.119
I have important beliefs and reasons for refusing to handle animals in the lab	26/104 (25.00)	29/104 (27.88)	25/104 (24.04)	16/105 (15.38)	8/104 (7.69)	11/104 (10.57)	22/104 (21.15)	26/104 (25.00)	28/104 (26.92)	17/104 (16.35)	**<0.001**

SD = Strongly Disagree; D = Disagree; N = Neutral; A = Agree; SA = Strongly Agree. Group comparison was done through Chi square test. Bold p values indicate a significant difference.

Table 3
Comparing level of confidence for students who 'Refused' and students who 'Accepted' to handle animals in the Pharmacology lab at baseline.

Baseline	Accepted (n = 107)					Refused (n = 105)					P value
	U	SU	NR	SC	C	U	SU	NR	SC	C	
I feel confident in handling animals in the Pharmacology lab	10/68 (14.71)	10/68 (14.71)	10/68 (14.71)	13/68 (19.12)	25/68 (36.76)	18/57 (31.58)	11/57 (19.20)	14/57 (24.56)	5/57 (8.77)	9/57 (15.79)	0.100
I feel confident in giving injections to animals in the Pharmacology lab	15/67 (22.39)	9/67 (13.43)	9/67 (13.43)	10/67 (14.93)	24/67 (35.82)	23/57 (40.35)	13/74 (17.54)	8/57 (14.04)	4/57 (7.02)	12/57 (21.05)	0.107
I feel confident in performing all parts included in the Pharmacology lab	7/67 (10.45)	8/67 (11.94)	14/67 (20.9)	17/67 (25.37)	21/67 (31.34)	13/57 (22.81)	12/57 (21.05)	10/57 17.54)	14/57 (24.56)	8/57 (14.04)	0.071

U = Unconfident; SU = Somewhat unconfident; NR = Neutral response; SC = Somewhat confident; C = Confident.

Table 4
Comparing students' level of confidence at baseline and end of the study.

Item	Time of study	Unconfident	Somewhat unconfident	Neutral response	Somewhat confident	Confident	* p value
I feel confident in handling animals in the Pharmacology lab	Baseline	43/177 (24.29)	30/177 (16.95)	39/177 (22.03)	23/177 (13.00)	42/177 (23.73)	0.184
	End of study	23/91 (25.30)	7/91 (7.70)	17/91 (18.65)	17/91 (18.65)	27/91 (29.70)	
I feel confident in giving injections to animals in the Pharmacology lab	Baseline	52/176 (29.50)	35/176 (19.90)	26/176 (14.80)	20/176 (11.40)	43/176 (24.40)	**0.017**
	End of study	25/92 (27.20)	7/92 (7.60)	15/92 (16.30)	22/92 (23.90)	23/92 (25.00)	
I feel confident in performing all parts included in the Pharmacology lab	Baseline	33/176 (18.75)	23/176 (13.05)	39/176 (22.15)	39/176 (22.15)	42/176 (23.90)	0.314
	End of study	20/90 (22.20)	7/90 (7.80)	24/90 (26.70)	13/90 (14.40)	26/90 (28.90)	

* Comparing pre to post assessments (Chi square test). Bold p values indicate a significant difference between baseline and end of study.

increased significantly at the end of the course (35.8% to 48.9%, p = 0.017). However, confidence in handling animals in the laboratory and performing all of the parts/ activities included in the Pharmacology laboratory experiments did not improve (Table 4).

Although a higher percentage of students who accepted to handle animals compared to those who refused, reported feeling confident to handle animals, to give injections, and to do all parts/activities included in the Pharmacology laboratory experiments, the differences were not significant at baseline. At the end of the study, students who accepted to handle animals reported significantly higher confidence in all three questions respectively, compared to those who refused (Fig. 2).

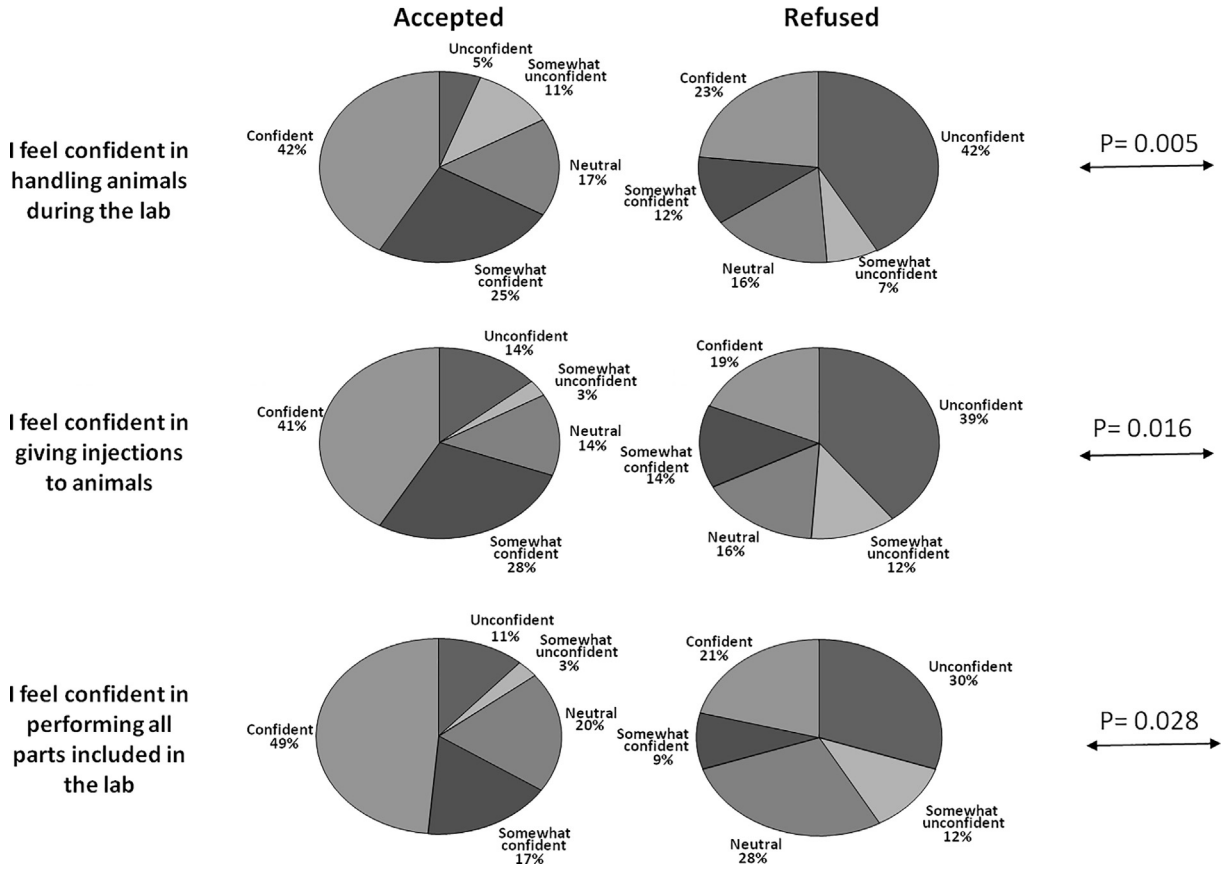

Fig. 2. Comparing students' level of confidence for students who 'Accepted' (n = 107) and 'Refused' (n = 105) to handle animals end of the study.

3.5. Focus group results

Students' answers to the focused questions indicated that the Pharmacology laboratory is very important in getting the knowledge and skills needed in this area of Pharmacy education and that verbal education in this domain would not be sufficient. All students agreed with animal handling in the laboratory is a better method for learning. Animal handling helped the students to gain the skills and knowledge needed to a great extent.

When asked about their feelings towards animal handling, students' opinions varied. Two students complained of uncontrolled phobia and one felt sorry for losing marks (15 marks) because of an issue that she considered was out of her control. Another student (a female) was worried about killing the animals by mistake, making her work unethical. Three students suggested that simulation (computer demonstration or watching videos) can be a good alternative to animal handling and that it is not necessary for each student to handle the animals. One student added that 'virtual reality (simulation) and other new technologies and approaches can be an option to making the learning experience interactive, without harming animals in the process. The rest of the students felt that simulation cannot replace animal handling in the Pharmacology laboratory and that it is too expensive.

All students stressed on the fact that the current Pharmacology laboratory, involving animal handling is very exciting and make students feel like real pharmacists, experimenting drugs and noting their effects. It is a different way of teaching, different to any other laboratory in the Faculty. All students believed that this type of hands-on education is important for their future career, as it makes them appreciate drug effects and be easy to work as researchers in the Pharmacology research field. None of the students agreed with animal handling being removed from the Pharmacology laboratory in the future. They suggested that group work involving students who accept to handle and those who refuse could resolve the issue.

Students suggested that they need more practice on animal handling before they actually start working with real animals. The current situation of dedicating one laboratory session towards this practice is not enough. Students start practicing with real animals before they are ready. Stuffed toys or other suitable simulation animal figures or computer programs can be used during this practice time to optimize the skills required. Train the trainer approach was suggested by the students. In that, the teaching assistant can teach one student, and that student can be responsible for teaching the students in his/her group.

4. Discussion

This study was conducted to take action by the academics at the Faculty of Pharmacy, ASU, towards the potentially revolutionary phase in the education arena, with regards to advancing and supporting a higher quality, ethical and democratic educational system. Current education aims to progress, by strengthening advances toward the implementation of promoting a less-strict hierarchical culture between students and their doctors, which is crucial to building critical thinking (Basheti, 2014; Basheti et al., 2010). Such egalitarian teaching and learning approaches can only be accomplished by listening to students' perceptions, needs, and barriers to learning (Basheti et al., 2015). Hence, to depart the traditional ways of teaching, to move away from the monotonous and passive student learning and to remain in the pace, student involvement will draw the future map of Pharmacology laboratory teaching at universities in the region.

The Pharmacology laboratory is an integral part of the Bachelor of Pharmacy curriculum. The objectives of pharmacology teachings are set to form a foundation of detailed knowledge of the medications, their mechanism of action, and rational prescribing. Pharmacology practical classes involve animal experiments, forming the important and integral parts of pharmacology syllabus at universities in Jordan and abroad. Animals are used in the laboratory to demonstrate the effects of various drugs on the animal (or its parts/ tissues in some laboratory sections). This lab presents the students with their first exposure to animal handling in their study years; although the students study a biology laboratory in their first Bachelor year, no such exposure is provided at that stage. Investigating students' perceptions revealed important barriers towards animal handling and the learning process followed in the laboratory. By acknowledging such barriers, resolutions and better future directions can be drawn, allowing to accomplish the learning outcomes set for this course, for every student enrolled in the laboratory. For a long time, students have been divided in the laboratory between those who agree to handle the animals (mice) while performing the experiments, and those who refuse, and preferred to take the role of 'observers' only. Students who refused animal handling lost marks (15% of the total mark) and reported negative outcomes when it came to acquiring the needed skills set in the objectives of the course. In this study, we were able, for the first time, to identify important students' barriers, which varied from phobia, reported by about half of the students who refused animal handling, refusing to work with animals not certified to be clean/pathogen-free, to perceiving lack of practice to handle animals as the obstacle.

With full acknowledgment that higher science education should be based on a humane approach, and the need to develop new alternative replacement methods to harmful animal use in laboratory training (Singh et al., 2016), students perceived distinctive benefits in animal use in this study. The overall confidence in handling animals and in giving injections improved by the end of the course for students who agreed to handle the animals compared to those who refused. In the focus group, students confirmed that by merely watching the teaching assistants and other students handling the animals does not provide the skills needed in performing the experiments. Students reported that barriers to animal handling can be resolved by providing richer individual practice till each student gains the skills needed to perform the actual animal handling in the experiments. Using stuffed animals for practice prior to real animal handling was also suggested and approved by all students. Providing certifications that guarantee the use of pathogen-free animals can be helpful to many students. Majority of the students believed that it is important to perform animal handling in practical Pharmacology laboratory and that animal handling in the laboratory is essential to understand the physiological effects of drugs.

Many students in this study were not sure if the benefits gained from testing drugs on animals in this laboratory made it ethical to harm or kill them. It was difficult to justify harming or killing animals for teaching purposes. Some students also reported that they felt 'sick' when they forced themselves to handle animals. Previously, students made their objection cases for animal experimentation public, and successfully attracted the attention of the local and national media (Knight, 2014). Many research studies have been conducted since the early 2000s, focusing mainly on undergraduate students' perception of animal use in education. This body of literature helped establish animal use as a controversial issue in the educational context in many countries around the world, highlighting the need for the promotion of a more humane approach to science education (Bachinski et al., 2015, 2017; Simkin et al., 2017).

Many researchers have favored the role of animal experimentation and their necessity for the advancement of medical knowledge, while animal right protection groups have always discouraged it (Ranganatha, 2012). This debate gained momentum

among the scientific community in the late 1950s, when Russell and Burch developed the concept of the Three Rs in animal experimentation (Ranganatha, 2012). In the principles, Russell and Burch introduced and defined the terms Replacement, Reduction, and Refinement, which subsequently have become known as 'alternatives' or 'alternative methods' for minimizing the potential for animal pain and distress in biomedical research (Ranganatha, 2012; Tannenbaum and Bennett, 2015). Hence, in recent years, development of alternatives to animal experiments is being focused; computer models can simulate different experiments within minutes (Hughes, 2001), decreasing the cost and time spent on animal experiments, compared to tedious animal models (Singh et al., 2016). These models act as a portal to carry the students into a better understanding of the physiology and the effect of drugs in humans. Both academics and students have shown encouraging response towards the use of these replacements to animal experiments (Dewhurst, 2007). However, humane education and the debate on alternatives to animal use for laboratory experiments and student training is a relatively recent issue in many countries around the world (Bachinski et al., 2015; Hart and Wood, 2004; Patronek and Rauch, 2007).

Similar to a previous study conducted in the University of São Paulo, Ribeirão Preto, São Paulo, Brazil, looking into perceptions of undergraduate students on the use of animals in practical classes (Rochelle et al., 2016), students in this study were divided between those who accepted animal handling and were afraid of missing out on professional skills if they refused and those who refused animal handling (due to barriers such as ethical concerns instigated by animal use). In the previous study, most students agreed that they had a good achievement (learned physiology) in practical classes with animals and that their use was important for learning (Rochelle et al., 2016). However, the majority of the students expressed mild to average discomfort when animals were used (Rochelle et al., 2016). Furthermore, most students agreed that there was a need for a discipline that contemplates bioethical issues on animal use (Rochelle et al., 2016).

Pharmacy institutions around the world have had a pivotal role to play at this crossroad. The curriculum of Pharmacy institutions in India considered the dynamic character of pharmacology, and the importance to prepare a syllabus that caters to the contemporary needs of the academic institutions (Bell et al., 2006). Redundant animal experiments were said to be replaced with the simulation experiments or those which are feasible in the light of stringent regulations of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) (Bell et al., 2006). At the University of Western Australia, responsible conduct in learning and research was progressively introduced into the Pharmacology curriculum for undergraduate science students (Fernandes, 2017). Students were introduced to issues such as the use of animals in teaching and the responsible conduct of research. This approach was found to be important for one's future career and stimulated further interest in this area (Fernandes, 2017). The European Convention for the Protection of Vertebrate Animals stated that any procedure carried out on animals for the purpose of education or training shall be restricted to those which are absolutely necessary and cannot be achieved by other comparably effective methods (Gettayacamin and Retnam, 2017; Hendriksen, 1994). Similar approaches are called for now in Jordan and other countries where animal use in the Pharmacology laboratory is still extensively employed in education.

Study limitations include conducting the study in one Pharmacy school in Jordan, using one cohort of third-year undergraduate Pharmacy students. However, no major differences are found in the way related educational methodologies are delivered in other schools of Pharmacy that can limit the generalization of the findings of this study. In addition, this is an inductive study that will facilitate further research in this area, and future studies should involve public and other private universities in the country. Students could have provided responses regarding their confidence in the direction they perceived to be desired by the investigators (socially desirability), however, the questionnaire was designed with 5 choices to allow students to provide accurate answers that were in line with their true level of confidence (Choi and Pak, 2005).

5. Conclusion

Ethics applicable to science have been evolved with regards to the use of experimental animals. In light of these directives, this study investigated animal experiments in the Pharmacology laboratory and revealed important students' perspectives and barriers to animal handling. Students reported phobia and ethical and other barriers to animal handling. Those who handled the animals showed better skills in certain areas at the end of the course than those who refused. Students perceptions concerning the use of simulated experimental models were positive, and they called onto more extensive initial practice using simulation models or toy animals before real animal handling in the lab. Engaging the students when making decisions regarding educational practices paved the way for change to the current traditional paradigm in the education of future scholars. In this manner, the educational system is being fortified to be more democratic and progressive.

Author contribution

Both authors have equal contributions in conducting this research and preparing the manuscript.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jsps.2018.05.020.

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