THE CHINESE UNIVERSITY OF HONG KONG

Micro-Module Courseware Development Grant

Scheme 3: eLearning Pedagogy Research

<u>Final Report (2015-16)</u>

<u>PART I</u>

Project title: Formal Effectiveness Assessment of a Mechanical Ventilation Micro-module for Final Year Medical Students

Principal supervisor: Prof. Chi Hung Czarina Leung

Co-supervisor(s) Prof. Charles Gomersall, Prof.Gavin Matthew Joynt, Dr.Wai Tat Wong

Department / Unit   Anesthesia and Intensive Care

Project duration: From February 2016 to January 2017

Date report submitted: December 2016

1. Project objectives

Is the project on track to meet its objectives?
Have the objectives been changed as a result of the experience of working on your MMCDG project?
Has the project created any impact as expected?

Our project's objective remained unchanged. We aimed to formally evaluate the effectiveness of this flipped-classroom approach using e-learning (including pre-reading e-chapter, interactive cases, summative assessment, online MV simulation, as well as a question and answer forum) and face-to-face (FTF) tutorials in teaching basic mechanical ventilation (MV) management. We also evaluated the utilization rate of the course material as well as student's feedback on the usefulness of the course. The students were also offered access to a smartphone application (app) for quick reference.

Yes, the project the project created the expected impact, which included improved student learning of a complex skill which required an integration of knowledge and practical competence. The course also achieved a high level of student motivation to utilize the courseware.

2. Process, outcomes or deliverables

Please specify the number of micro modules produced, and the course(s) (with course codes and titles) that have used the micro modules in Part IV, and provide more detailed descriptions in here. x
Have the research design, methodology and timeline been changed/adjusted?
Overall, was the project completed satisfactorily?

This project created one micro-module with e-learning, face to face tutorial and a smartphone application. The micro-module was delivered as part of the undergraduate curriculum for teaching final year medical students acute medicine in the Very BASIC course.

The research design, methodology and timeline were not changed. The project was completed satisfactorily.

3. Evaluation Plan

Have you altered your evaluation plans?
Does your evaluation indicate that you have achieved your objectives?

No, the evaluation plan was unchanged. Yes, the evaluation results indicated that our objectives were achieved.

1. Evaluation of effectiveness of the micro-module to improve students' competence in MV management:

   Two critical care educators, informed only of the syllabus outline but not of the course content, created the knowledge and skills assessments at a level expected of interns. This evaluation method was designed to provide impartial assessment of the pedagogical value of the course in terms of students' competence.

   Knowledge was assessed by pre- and post-course multiple choice questions (MCQs) testing 10 domains of MV. For each student, two MCQs of equal difficulty per domain were randomized to pre- and post-course tests (Table 1). The two educators conducted 10-minute post-course skills testing of students' practical competence in setting the correct MV mode, FiO_2, tidal volume, respiratory rate (RR), PEEP in a case scenario; performing appropriate action in response to desaturation, pressure or RR alarms; reassessing after setting or adjusting MV (Table 2). All student participants undertook the MCQs. Due to time limitations, 23 students were randomly selected to take part in the skills test.

Table 1. Knowledge Test - MCQ domains and questions

Domains	Questions
Q1 Ability to select initial setting for patient with normal lungs	A 50-year old, 65 kg female patient is admitted to your ward because of hypnotic agent overdose. She has a GCS of 6/15 but has regular spontaneous breathing observed. Bedside previous repeated admission for drug overdose, she had no past medical history. Your colleague is manually ventilating the patient and you are asked to provide setting for the ward ventilator. The following initial ventilation settings are the best suited one for this patient:
Q2 Ability to select initial setting for patient with COPD	A 66-year old, 75 kg man presents with shortness of breath and increased sputum production over about 3 days. He is a known smoker, and has been receiving medications for treatment of his COPD. He became exhausted. You notice he has consistent spontaneous breathing shortly after the intubation and manual bagging by your senior. Arterial blood gas before intubation shows a pH of 7.28, PaO_2 of 7.8 kPa, and bicarbonate of 27 mmol/L. Your senior asks you to set the MV in the ward. The best initial settings should be:
Q3 Ability to select initial setting for patient with brain injury	A 35 year-old, 80kg man is just admitted after head injury from a bicycle accident, his GCS drops from 9/15 to 4/15 after the CT scan is performed. His CT scan shows a right side epidural haematoma with mid line shift. Your colleague has intubated this patient and administered sedation and muscle relaxant IV infusion, with added mannitol. She asks you to provide the initial setting of the portable MV for transport of the patient to the operating theatre. The following settings are the most appropriate for this patient:
Q4 Ability to select initial setting for patient with sepsis	The nurse calls you to see a patient (60 kg woman) who is intubated and receiving volume preset assist control. He was previously stable. He is sedated, intubated and on MV. The patient's SaO_2 is 84%. MV screen with waveforms is shown. The best immediate management, in order provided, is as follows:
Q5 Ability to adjust setting for abnormally high or low PaCO2	A 55-year old, 60 kg male patient is admitted to your ward after a collapse in the Accident & Emergency Department. He is deeply comatose (GCS is 4/15), and has cerebral swelling seen on CT scan. He is paralyzed with muscle relaxant and ventilated with volume preset assist control. His SaO_2 is 100%. He was previously well, and otherwise had no history of previous medical or surgical problems. Arterial blood gas shows a pH of 7.29, PaO_2 of 15.8 kPa, $PaCO_2$ of 7.8 kPa, and bicarbonate of 28 mmol/L. He is awaiting OT transfer. MV screen with waveforms is shown. You are asked to adjust the settings for the ward MV.
Q6 Ability to adjust setting for abnormal tidal volume	A 35 year-old, 85kg man is just transferred back from OT after operation for his epidural haematoma from head injury. He is still deeply comatose after the general anaesthesia and on MV though an endotracheal tube. His SpO_2 is 97%. MV screen with waveforms are shown. His arterial blood gas result is as follows, pH of 7.48, PaO_2 of 12.8 kPa, $PaCO_2$ of 4.2 kPa, and bicarbonate of 23 mmol/L. The nurse asks you to make adjustment to the MV setting. The following response to the nurse is the best at this moment:
Q7 Ability to know when change between volume-preset assist control and pressure support modes	A 55-year old male patient is admitted for heroin overdose. He is deeply comatose with GCS 3/15. He is intubated and put on mechanical ventilator support 15 minutes ago. The MV waveform on a MV screen is shown. The nurse calls you because his blood pressure is low (BP: 80/40). Your most appropriate response is:
Q8 Ability to troubleshoot for desaturation	A 45-year old, 60kg lady is being ventilated for 1 day because of severe pneumonia. A nurse call you urgently to assess this patient because his SpO_2 drop from 98% to 85% over the past 30 min. MV waveform is shown. What will be you next steps of management?
Q9 Ability to troubleshoot for high airway pressure alarm	A 75 year old patient with pneumonia was admitted to your ward 5 days ago. He now has a clearing chest X-ray and body temperature is normalized. Sedation has been stopped. Arterial SpO_2 is 97%. MV waveform is shown. What will be you next steps of management?
Q10 Ability to troubleshoot for hypotension in mechanically ventilated patient	A 75 year-old patient has been recovering from acute pulmonary oedema. He was switched from volume preset assist control mode to pressure support mode 4 hours ago. His current ventilator setting is pressure support mode: PS: 8 cmH_2O, FiO2 0.4, PEEP 5 cmH_2O. His SpO_2 has decreased from 98% to 88% in the past 4 hours, and the nurse informs you that he is breathing more rapidly with breathing rate of 28/min. Your next appropriate action is:

3

Table 2. Practical Skills test. Aspects of clinical competence are evaluated

	Task to be finished	Response	Marks	
1	Set the mode of the ventilation?	Volume Preset Assist Control mode	1	
		SIMVmode	0.5	
2	Set the FiO2	60%-100%	1	
		<60%	0.5	
3	Set the tidal Volume and Resp rate	<560ml	0.5	
	Set the resp rate to achieve a MV of >100ml/kg/min	>13-17/min (corresponding to TV of 420-560ml)	0.5	
4	Set the PEEP	4-12cmH2O	1	
5	Next action after connected the patient to the ventilator	Exam the patient	0.5	
		Check the blood gas 10-20min later	0.5	
6	Reset the high pressure alarm	25-40cmH2O	1	
		15-25cmH2O	0.5	
7	Reset the high resp rate alarm	25-35/min	1	
8	Increase the rate	Rate =>15	1	
	Increase tidal volume	<560 ml	1	
9	Decrease FiO2	FiO2 < 1.0	0.5	
		Same FiO2	0	
10	Next action after reset the ventilation	Check the blood gas 10-20min later	0.5	
		Total Calculated Score (out of 10)		
		Overall Competence Impression mark (out of 10)		

Our results show that students' knowledge improved in every domain of MCQ test (McNemar's test, P-values varied from <0.001 to <0.03). Mean score (95% CI) increment 7.0 (0.8 to 13.1) improved to 32.6 (28.7 to 36.6) with FTF participation (p<0.001). Median skills test score was 8/10 (IQR 6.75 – 8.5) .

2. Evaluation of students' perception and behavioural indication of the usefulness of this micro-module:

- Students' participation in different sections of the course was recorded to evaluate their level of motivation to participate in this learning opportunity.

  Our results show that 179 of 220 (81%) final year medical student in the class of 2016/2017 opted to indicate participate showing high level of motivation to use the micro-module. The relationship between use of specific components of the micro-module with the MCQ scores are shown below, suggesting that the face to face tutorial is essential for improving students' knowledge.

Table 3. Results: course component utilization and MCQ score improvement

Component of module utilized	Mean (95% CI) increment Score
none	7.7 (-1.6 to 17.1)
e-learning only	7.0 (0.8 to 13.1)
e-learning + face to face tutorial	32.6 (28.7 to 36.6)

- Their perceived level of usefulness of the micro-module was evaluated by feedback surveys. Our results show that students rated course useful with median score of individual components 4-5 (IQR 4-5); 4 = agree, 5 = strongly agree

Table 4. Students' feedback on the MV micro-module

	Median	IQR
Q1. The ventilation simulator was easy to use	4	3-4
Q2. The ventilation simulator ran smoothly without faults	4	3-4
Q3. The online case scenarios ran smoothly without faults.	4	3-4
Q4. The ventilation assessment ran smoothly without faults	4	3-4
Q5. The chapter improved my ability to use mechanical ventilation	4	4-5
Q6. The interactive ventilation simulator improved my ability to use ventilators	4	4-4
Q7. The online case scenarios improved my ability to use ventilators	4	4-4
Q8. The face-to-face tutorial improved my ability to use ventilators	4	4-5
Q9. I would recommend this mechanical ventilation module to other students	4	4-5
Q10. The content as a whole is useful in preparing me to work as a doctor	4	4-5
Q11. I would use the ventilation simulator again when I am an intern	4	3-4

Q12. If a mechanical ventilation guide in the format of a mobile phone digital application is available, I would use it during my clinical attachment	4	4-5

- The smartphone utilization log of both 2015-2016 and 2016-2017 student classes were evaluated as the latter class have not yet graduated, as such the additional evaluation of the previous year's graduates' app use data provides insight into continued use after graduation.

Our results show that a significant proportion of the students used the smartphone application during the micro-module, before their graduation and after graduation.

Table 5. Number of students who used the smartphone application during the micro-module, after the micro-module but before the final exam, and after graduation (after the final examination)

	2015/2016 class	2016/2017 class
During micro-module	15	100
Between after micro-module and final exam	32	32 (this period goes up to now and is incomplete as student's still approximately 6 months before their final exam)
Post Graduate	16	This period has not yet started.

4. Dissemination, diffusion and impact

Please provide examples of dissemination: website, presentations in workshops or conferences, or publications.

Please provide examples of impact: how the research results/outcomes/findings can be extended to other disciplines.

Please describe how the research results/outcomes/findings may support the University's strategic aims in promoting eLearning.

We will disseminate this project by:

1) CUHK's Teaching and Learning Innovation Expo 2016 – poster and presentation
2) We have submitted the abstract to the international conference "37th International Symposium on Intensive Care and Emergency Medicine" (results pending)
3) We have submitted a full manuscript for publication at the journal "Medical Education" (results pending)

PART II
Financial data

Funds available:

Funds awarded from MMCDG $ 146062

Funds secured from other sources $
(please specify_____)

Total: $ 146062

Expenditure:

Item	Budget as per application	Expenditure	Balance
I) Teaching relief - project leader's time for: 1) Setting up and running additional face-to-face clinical teaching 2) Setting up new MCQ and skills testing 3) Data analysis 4) Write up of publication	Yes	60000	86062
II) Teaching relief for one ICU Consultant and one Clinical Professional	yes	60000	26062

Consultant to: 1) Write MCQs and clinical examination assessment 2) Run skills tests			

III) Technology technician expertise and service for:
   1) Set up data collection program for phone application (3 days)
   2) Creation of versions of the phone application that can be utilized in different phone platforms (4 days)
   3) Maintenance and troubleshooting of e-learning and phone application (5 days)
   4) Update of e-learning and phone application (5days)
   5) Setting up and running skills stations and skills tests (10 days)
	Yes	26062	0

Total:			146062

PART III

Lessons learnt from the project

Please describe your way forward.
Please describe any of the following item(s) accordingly:
- *Key success factors, if any*
- *Difficulties encountered and remedial actions taken, if any*
- *The role of other units in providing support, if any*
- *Suggestions to CUHK, if any*
  - *Example: what should be done differently?*

The course is a time-efficient and effective approach to improve students' MV knowledge and skills. Although FTF appeared to be necessary, we believe that it must be preceded by e-learning as one-hour FTF is insufficient to provide the background and practice skills teaching. Furthermore, students showed motivation to participate and found the training useful. The courseware is freely available to other educators and therefore only requires

clinical teachers to provide one-hour FTF sessions. This blended learning approach with online scenario-based learning with simulator as well as FTF tutorial may be applicable for teaching in complex skills in other topics, whether within or outside of medicine.

The formal testing method provided an impartial evaluation of students' learning and the courseware's pedagogical values. Assessors were blinded to the course content and set the evaluations at a level of difficulty expected of interns. This external validation process also facilitating identification of areas for improvement of the course, e.g. it was identified during the skills test that although the students understood in concept that when low oxygen level is detected, patients should be disconnected from the MV and receive oxygen via a handheld device, however in reality many students did not how to connect the handheld device to the patient. Furthermore, the evaluations were split into MCQs for knowledge assessment and skills test for practical competence examination as both were deemed important for complex skills learning. To provide evaluation that were not affected by differences in the difficulty of MCQs, we randomized two questions of equal difficulty in each domain to the pre- and post-module test for each student. This mode of pedagogical evaluation may be used for further micro-module.

PART IV
Information for public access

Summary information and brief write-ups of individual projects will be uploaded to a publicly accessible CUHK MMCDG website. Please extract from Part I the relevant information to facilitate the compilation of the publicly accessible website and reports.

1. Keywords

Please provide five keywords (in the order of most relevant to your project to least relevant) to describe your micro-modules/pedagogies adopted.

(Most relevant)   Keyword 1: flipped-classroom

Keyword 2: blended learning

Keyword 3: e-learning

Keyword 4: simulation

(Least relevant)   Keyword 5: mechanical ventilation

2. Summary

Please provide information, if any, in the following tables, and provide the details in Part I.

Table 1: Publicly accessible online resources (if any)

(a) Project website:

If a publicly accessible project website has been constructed, please provide the URL.

Moodle: http://web8.aic.cuhk.edu.hk/moodle/?
Then select "Very BASIC & Patient Safety@CUHK 2016 ", then "Very BASIC Mechanical ventilation". This requires a login and password, please contact the principal supervisor to arrange access if applicable.

(b) Webpage(s):

If information of your project is summarized in a webpage (say a page in the department's or faculty's website), please provide the URL(s) in here.

Then select "Very BASIC & Patient Safety@CUHK 2016 ", then "Very BASIC Mechanical ventilation".

(c) Tools / Services:

If you have used any tools or services for the project, please provide names of the tools or services in here.

1) Moodle as the platform for disseminating e-learning

2) Mechanical ventilator simulator was provided by Hamilton Medical for educational purposes

3) Technology technician to:
   a. Set up data collection program for phone application
   b. Creation of versions of the phone application that can be utilized in different phone platforms
   c. Maintenance and troubleshooting of e-learning and phone application
   d. Update of e-learning and phone application

4) Critical care educators to:
   a. Write MCQ assessment
   b. Run skills assessments

(d) **Pedagogical Uses:**

If any flipped classroom activities have been conducted, please provide information in here. If relevant, please indicate how your project output can be used to support flipped classroom activities.

The courseware consisted of an e-chapter (written to introduce basic MV settings and physiology); online interactive cases and practice tests with a MV simulator (created to facilitate scenario-based practice. The simulator was provided by Hamilton Medical) on Moodle; question and answer forum on Moodle; a one-hour FTF tutorial (1 teacher to 6 students); and a smartphone application (for quick reference).

Table 2: Resource accessible to a target group of students (if any)			
If resources (e.g. software) have been developed for a target group of students (e.g. in a course, in a department) to gain access through specific platforms (e.g. Blackboard, facebook), please specify.			
Course Code/ Target Students	**Term & Year of offering**	**Approximate No. of students**	**Platform**
Eg1. DEPTXXXX	*1st term 2015*	*50*	*Blackboard*
Eg2: Dept of xxxx	*All 1st year students*	*40*	*facebook*
	All final year medical students in class of 2015/2016 and 2016/2017	In the class of 2016/2017, 179 of 220 (81%) students opted to participate in the micro-module study. In the class of 2015/2016, 131 out of 180 students (76%) used the micro-module.	We delivered the online courseware through Moodle. We delivered the face to face tutorial during the Very BASIC course. We provide a quick reference of the e-chapter on the Very BASIC smartphone application, which all medical students have access to during and after the study period
Table 3: Presentation (if any)			

Please classify each of the (oral/poster) presentations into one and only one of the following categories	Number
(a) In workshop/retreat within your unit (e.g. department, faculty)	*Please insert no*
(b) In workshop/retreat organized for CUHK teachers (e.g. CLEAR workshop, workshop organized by other CUHK units)	*Please insert no*
(c) In CUHK ExPo jointly organized by CLEAR and ITSC	*1 poster presentation* *1 oral presentation*
(d) In any other event held in HK (e.g. UGC symposium, talks delivered to units of other institutions)	*Please insert no*
(e) In international conference 37th International Symposium on Intensive Care and Emergency Medicine in Brussels, March 2017.	*Potentially 1 poster presentation* *(results pending)*
(f) Others (please specify)	*Please insert no*

Table 4: Publication (if any)	
Please classify each piece of publications into one and only one of the following categories	**Number**
(a) Project CD/DVD	*Please insert no*
(b) Project leaflet	*Please insert no*
(c) Project booklet	*Please insert no*
(d) A section/chapter in a booklet/ book distributed to a limited group of audience	*Please insert no*
(e) Conference proceeding 37th International Symposium on Intensive Care and Emergency Medicine	*Potentially 1 abstract publication at Critical Care (results pending)*
(f) A chapter in a book accessible internationally	*Please insert no*
(g) A paper in an referred journal	*Potentially 1 paper publication Medical Education (results pending)*
(h) Others (please specify)	*Please insert no*

3. **A one-page brief write up**

Please provide a one-page brief write-up of no more than 500 words and a short video.

Background: Manage mechanical ventilation (MV) is a complex skill that requires integration of knowledge and practical application to acutely ill patients. Limited real-life learning opportunities make teaching complex skills difficult.

Objectives: To evaluate effectiveness of a blended learning module in achieving medical students' knowledge and practical competence in MV operation.

Methodology: We performed a prospective cohort evaluation of the pedagogical effectiveness of an optional blended learning module on MV operation in two consecutive intake of final year medical students. The module consisted of e-learning - online pre-reading chapter (to introduce basic MV settings and physiology), online interactive cases and practice quizzes to be used with a MV simulator and a discussion forum on Moodle. (to facilitate scenario-based practice); as well as a one-hour face-to-face (FTF) tutorial (Figure 1-3).

Ethical approval has been obtained from the Survey and Behavioural Research Ethics Committee (SBREC) of The Chinese University of Hong Kong. Participants all provided Informed consent.

Students' MV knowledge and practical competence were evaluated. Two critical care educators, informed only of the syllabus outline, set the knowledge and skills assessments at a level expected of interns. Knowledge acquisition was evaluated by pre- and post-course multiple choice questions (MCQs) testing 10 domains of MV (Table 1). Two MCQs per domain with equal difficulty were randomized to the pre- and post-course test per student. Practical competence was evaluated by a 10-minute post-course skills test (Table 2).

Students' feedback on the usefulness of the course was surveyed.

Results: 179 (81%) final year medical student classes opted to participate in the final medical student classes of 2016/2017. Knowledge improved in every domain of MCQ test (McNemar's test, P-values varied from <0.001 to <0.03). Mean score (95% CI) increment 7.0 (0.8 to 13.1) improved to 32.6 (28.7 to 36.6) with FTF participation (p<0.001) (Table 3). Median skills test score was 8/10 (IQR 6.75 – 8.5).

Students rated course useful with median score of individual components 4-5 (IQR 4-5); 4 = agree, 5 = strongly agree (Table 4).

Conclusion: The blended learning approach with e-learning and one-hour FTF teaching was effective in teaching a complex skill, significantly improving students' knowledge and skills. The FTF component appeared to be crucial to performance, however we believe the preceding e-learning is also important because one-hour of FTF is insufficient to provide both the needed background as well as practical skills guidance.

Randomization of MCQs minimized differences in the difficulty of pre- and post-course tests. Assessment by blinded educators was designed to provide an impartial evaluation of the students' level of competence and therefore the modules pedagogical effectiveness.

Students showed high level of motivation to learn and the module was perceived to be useful.

This pedagogical approach may be useful for complex skills training in other topics.

Figure 1. e-learning by Moodle
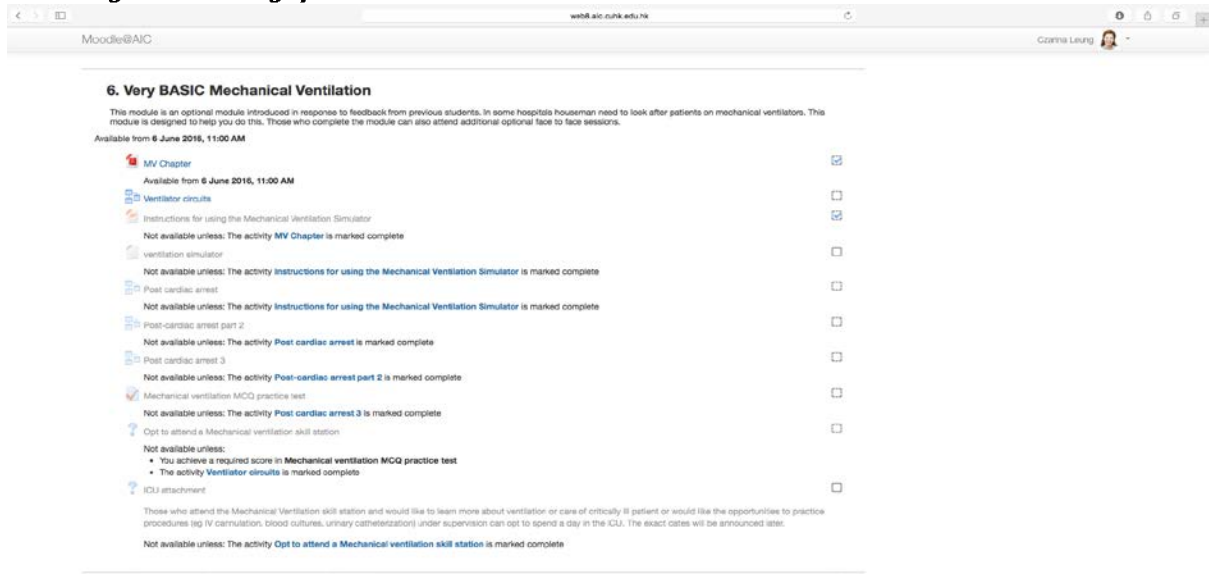
Figure 1. e-learning by Moodle

Figure 2. MV Interactive cases on Moodle
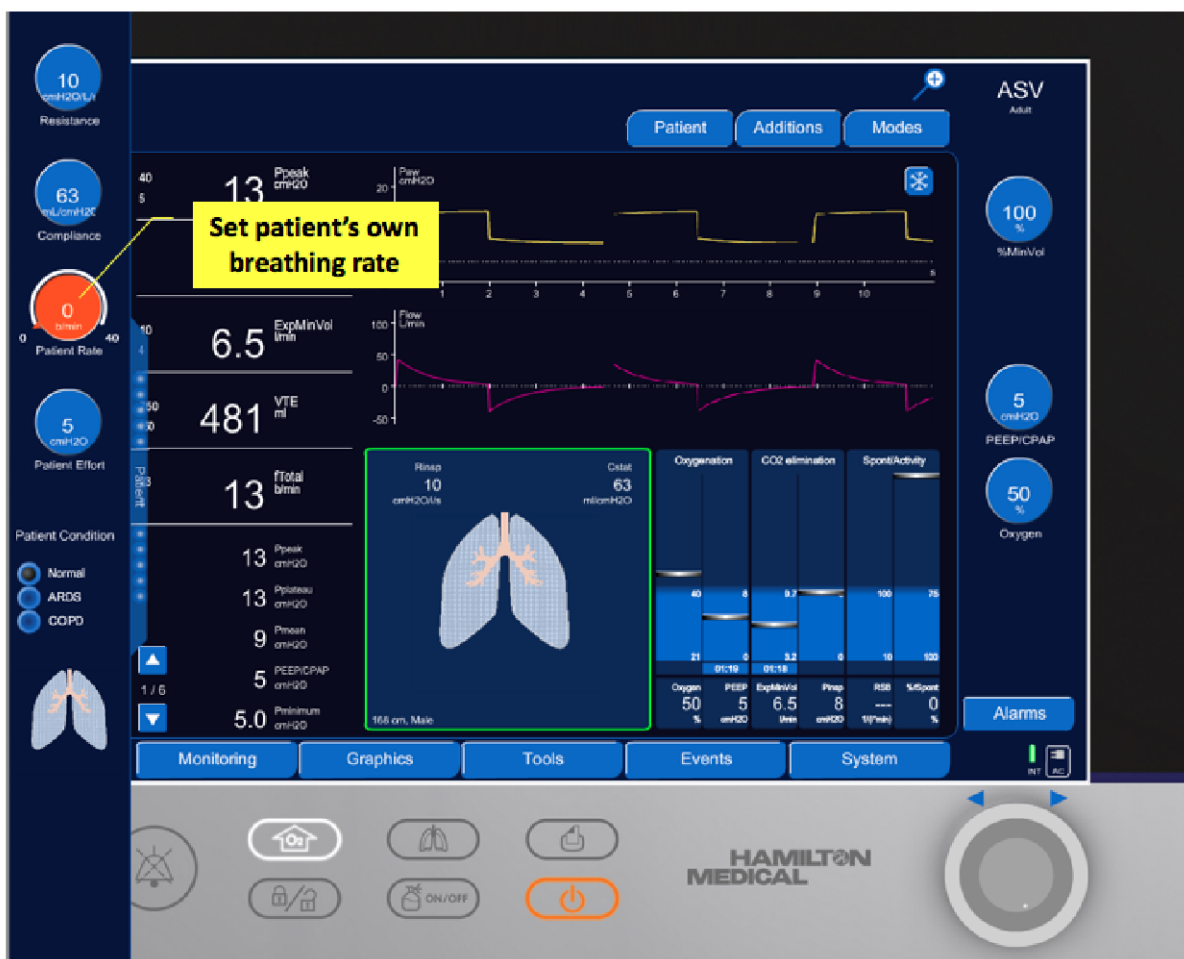
Figure 3. MV Simulator on Moodle

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		15-25cmH2O	0.5	
7	Reset the high resp rate alarm	25-35/min	1	
8	Increase the rate	Rate =>15	1	
	Increase tidal volume	<560 ml	1	
9	Decrease FiO2	FiO2 < 1.0	0.5	
		Same FiO2	0	
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		Total Calculated Score (out of 10)		
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Q3. The online case scenarios ran smoothly without faults.	4	3-4

Q4. The ventilation assessment ran smoothly without faults	4	3-4
Q5. The chapter improved my ability to use mechanical ventilation	4	4-5
Q6. The interactive ventilation simulator improved my ability to use ventilators	4	4-4
Q7. The online case scenarios improved my ability to use ventilators	4	4-4
Q8. The face-to-face tutorial improved my ability to use ventilators	4	4-5
Q9. I would recommend this mechanical ventilation module to other students	4	4-5
Q10. The content as a whole is useful in preparing me to work as a doctor	4	4-5
Q11. I would use the ventilation simulator again when I am an intern	4	3-4
Q12. If a mechanical ventilation guide in the format of a mobile phone digital application is available, I would use it during my clinical attachment	4	4-5