Review of Use of Animation as a Supplementary Learning Material of Physiology Content in Four Academic Years

Isabel Hwang[1], Michael Tam[1], Shun Leung Lam[2] and Paul Lam[2]
[1]School of Biomedical Sciences, The Chinese University of Hong Kong, Hong Kong, China
[2]Centre for Learning Enhancement And Research, The Chinese University of Hong Kong, Hong Kong, China
isabelss@cuhk.edu.hk
mtam@cuhk.edu.hk
learn.lam@cuhk.edu.hk
paul.lam@cuhk.edu.hk

Abstract: Dynamic concepts are difficult to explain in traditional media such as still slides. Animations seem to offer the advantage of delivering better representations of these concepts. Compared with static images and text, animations can present procedural information (e.g. biochemical reaction steps, physiological activities) more explicitly as they show the steps in an orderly manner. Quite a few empirical studies showed promising results animations have on learning (e.g. Trevisan, Oki and Senger, 2009; Hays, 1996). There are, however, also limitations. Designing and developing quality animations for teaching and learning can be challenging sometimes (Morrison, Tversky and Betrancourt, 2000). Kesner and Linzey (2005) even found no improvement on students' learning in using animations in their study. It thus occurs to the researchers that there are factors that govern successful use of animation in teaching and learning. Our study explored such factors in the context of physiology teaching. 913 students in twelve different classes (collected in two stages, four years in total) in the same physiology course learned complicated microscopic mechanisms with assistance from animations provided as supplementary materials primarily for self-study. Surveys and group interviews were conducted that provided both qualitative and quantitative feedback. Results were mostly positive - animations surely explain contents more explicitly to students (especially for the explanation of dynamic and complicated biological processes), make students more interested in the subjects taught; and there is a greater demand for similar learning tools from the students. It is strongly believed that animations are good supplementary learning materials for students particularly for learning complicated concepts. Important success factors we found included the detailed explanation of content, a good balance between clear presentation and beautiful interface, the speed of running/ loading of the animations, and the provision of more references, etc.

Keywords: teaching dynamic physiology process, supplementary use of animation, advantage of animation in teaching, successful factors of using animation, animation for student revision, learning with animation

1. Animation in teaching and learning

Dynamic concepts are difficult to explain in traditional media such as still slides. Animations seem to have the advantage of delivering better representations of these concepts. A wide range of subject areas such as chemistry and computer sciences are currently using animation to demonstrate their course contents (e.g. Kehoe, Stasko and Taylor, 2001; Payne, Chesworth and Hill, 1992; Dyck, 1995; Harrison, 1995; Tversky and Morrison, 2001). Similarly, Kesner and Linzey (2005) remarked that animation can be applied in the study of physiology, such as presenting modules covering the muscular, respiratory, urinary, cardiovascular and nervous systems.

There are claims about the advantage of using animation over traditional paper-based explanation. Lowe (2004) suggested that animations have the potential to serve both affective function and cognitive function. Affective function refers to portraying things in a humorous, spectacular, or bizarre way so that learners will be attracted to pay additional attention on the learning materials and motivated to learn.

Cognitive function refers to the clear presentation of dynamic matters (which might be abstract and difficult) that can allow learners to understand in an easier way. Compared with static images and text, animations can present procedural information (e.g. biochemical reaction steps, physiological mechanisms) more explicitly as they show the steps in an orderly manner. Hegarty (2005) mentioned that animation is used for representing the mechanical motions directly while static images could just show the motions indirectly through arrows and phase diagrams. She carried on suggesting that animations bring "more realistic representations, that is more isomorphic to the reality they represent"

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(Hegarty, 2005: 451). Moreover, we think animations allow representations of objects that are either too microscopic (e.g. viruses, nuclei) or even invisible (e.g. electricity current, magnetic force) for the naked eyes. Details can be viewed from angles not feasible in real life.

A number of empirical studies showed promising results animations have on learning. Trevisan, Oki and Senger (2009) compared two groups of students who used a video of traditional lecture and animation as the learning material respectively. The learning topic was about follicular dynamics, a topic in physiology. The students invited for the study were from an undergraduate reproductive physiology course in six universities in USA. An immediate one-off test was used as the evaluation instrument. The results in general showed that those used animation as the learning material got significantly higher marks.

Hays (1996) reported a study of using three different media: animation, static graphs, and textual material. They were for students to learn the movement of molecules, the effects of heat and pressure on molecules movements, and how molecule diffused from different concentrations. Students were divided into groups of high and low spatial ability and they were asked to use the three different media to learn. A test was administrated at the end to compare the learning performance of students in each group. The results showed that animation was effective to help students who were low in spatial ability.

There are, however, limitations concerning with the use of animations in teaching and learning. Designing and developing quality animations for teaching and learning can be challenging. Morrison, Tversky, and Betrancourt (2000), for example, remarked that fast-paced animations would impose difficulties to the students in observing detailed procedural information. Moreover, animations are costly and time-consuming to make. Viewing them may be time-consuming too. If a concept can be understood using a static diagram or using text, it will be time-saving.

Kesner and Linzey (2005) found no improvement on students' learning in using animations. A learning package was developed for students to learn physiology. Animations were an important component of the learning package. The students were studying courses of human anatomy and physiology in a university in Midwestern USA. The materials were used as a supplementary learning material. The time students spent on using the learning package and their examination results were compared. The result was that use of the package "did not have a significant impact on student performance" (Kesner and Linzey, 2005: 211).

Morrison, Tversky, and Betrancourt (2000) reviewed more than 12 previous studies that were about the comparison of static graphics and animations, with follow-up tests/ tasks scores as indicators. They concluded that real benefits (in terms of student scores) of animations to learning were not found in at least four of the studies. Even for the studies that students who used animations outperformed those who did not, Morrison, Tversky, and Betrancourt thought that the benefits were not a result of animations alone but were a combination of the followings: The animations contained additional or important information, while the static graphics did not (in the studies of Large, Beheshti, Breuleux and Renaud, 1996; Rieber, 1990, 1991a, 1991b); the number of static graphics used was not enough since the molecular steps of the processes were not shown (in the studies of Park and Gittelman, 1992; Lee, 1997); or the method of study was not well designed (in the study of Kieras, 1992).

In this study, it is considered that a comparison of animations with text/ pictures will not be meaningful in the actual teaching and learning context because animations are always used as supplementary learning materials in the real setting. The research focus of the present paper, therefore, is on following:

- What are the roles of animations in supplementing learning?
- How should teachers and courseware developers attend to the various design features of animations and improve them, for bringing more learning benefits to students?

2. Our study background

Our students are students in a foundation physiology course in The Chinese University of Hong Kong. Students taking this course are majors in a range of disciplines: Pharmacy, Medicine, Chinese Medicine, Human Biology and Nursing. Almost all of the students are year 1 students. It was expected that animation would be a good tool for learning many physiology concepts as many topics in this field of study are complex, occurring at the molecular level which is not observable, and involving multiple steps and/or multiple components, such as the working mechanisms of electrical signal generated in the nerve cell, contraction and relaxation of skeletal muscle fibers and reabsorption of water in different segments of the kidney tubules.

Starting in 2008, with the support of Courseware Development Grants, four online animation modules have been developed on topics in action potential (AP), skeletal muscle contraction (SMC), cardiovascular physiology (CP) and urine formation in kidney (UK). The animations served as supplementary learning materials primarily for students' self-study at home. Some animations were also chosen and also played during lectures to reinforce key physiological concepts before students spend time reviewing the animation module again at home.

These animations were used by twelve classes of full-time students in two stages (four years in total) who took the physiology course. In Stage 1 (2008–2009 and 2009–2010) the animations were used as supplementary learning materials in eight classes. Students' comments and suggestions about the animation courseware were collected for the research team and the teacher to learn about the effectiveness and usefulness of the animation courseware. The courseware was then slightly modified according to some useful suggestions from students, and was then adopted in four classes in Stage 2 (2010–2011 and 2011–2012). Stage 2 served as a follow-up study of the effectiveness and usefulness of the animation courseware, as to let the teacher and the research team to confirm factors that influence learning effects of animations.

Great care has been paid to the designs of the animations to maximise the learning potentials of these supplementary learning materials and make our effort worthwhile. Pedagogical and technical services from the Centre for Learning Enhancement And Research (CLEAR) and Information Technology Services Centre (ITSC) have been used. Significant effort has also been paid to evaluate the materials through surveying the students and meeting some of them over the four years of use.

Mayer (2002) proposed a cognitive theory model in order to explain the effects of multimedia materials on learning. In this model, cognition performs in the following ways: dual channel assumption (learner processes visual and auditory information through separate channels), limited capacity (learner's working memory is limited that he can only process in each channel at one time) and active processing (learning is the process of the learner's integrating the information received with other information). Based on these assumptions and supported with empirical evidence, Mayer carried on and made the following suggestions for an effective learning material.

- Giving explanations/ remark next to the image instead of far away from the image;
- Providing narration to the animation simultaneously instead of successively;
- Eliminate extraneous words, pictures and sounds;
- Using pictures and words are better than words alone;
- Animation with narration is better than animation with words;
- Animation with narration only is better than animation with narration and words;
- Allowing students to have prerequisite knowledge about the objects in the animation at first is better than without such knowledge;
- Telling students the summary or letting them know "how the ideas are organized into a causal chain" (p. 128) is better without that;
- Present the words in conversational style is better than formal style.

The following table is about how our animations in both stages corresponded to these features. Figure 1 shows the layout of one of our animations (AP module) and illustrates how these considerations influenced our animations.

Table 1: Mayer's (2002) nine features and the fulfillment of our animations

Feature	Do our animations fulfill this feature?
(i). Giving explanations/ remark next to the image	Yes, there are labels next to the objects in the animations.
(ii). Providing narration to the animation simultaneously	The animations are narrated (learners can alternatively choose to mute narrations).
(iii). Eliminate extraneous words, pictures and sounds	Yes, the animations are concise.
(iv). Animation with narration is better than animation with words	Yes, narrations are provided.
(v). Animation with narration only is better than animation with narration and words	Words are considered to be necessary as the scripts contain key terms students need to know. The scripts of the narrations are also displayed concurrently as captions on the screen. The design is to suit students with different learning preferences and abilities.
(vi). Allowing students to have prerequisite knowledge about the objects	Difficult terms are further explained in glossaries. Students can pause the animation at a point of difficulty and check for more explanations of the key terms.
(vii). Telling students the summary	Students are also given a sense about how the current step being viewed is situated in the overall model through a timeline represented concurrently on the screen. It is thought this design assists in understanding of the whole issue at hand.
(viii). Present the words in conversational style	Effort has been paid to use easy English.
(ix). Using pictures and words are better than words alone	Yes.

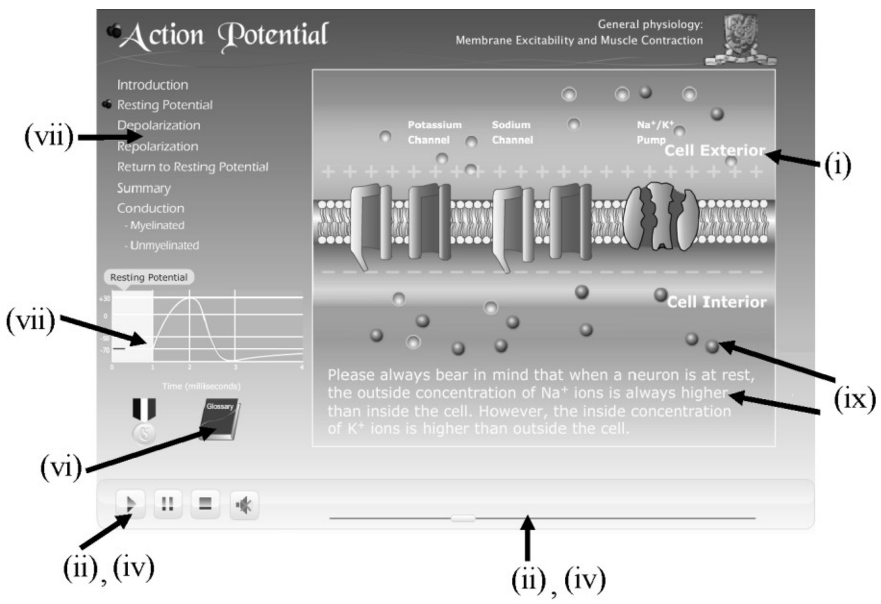

Figure 1: Screen capture of the AP module

Apart from the above considerations, we also took effort to ensure that:

- The animations are professionally prepared: colourful, high-quality images that are attractive to the viewers and motion of components at molecular level that are also run smoothly. It is aimed at providing visualisation of complicated molecular processes with clearer and graphically richer features when compared to text or static graphics.
- Students have full control of how the animations are played – through using the VCR-type button controls or through using the sliding bar. In this way, a certain step in the processes in the animations can be played slowly, paused, revisited or skipped depending on the needs of individual learners.
- Students can view them in any sequence they like. There is no prescribed learning path.
- Students are constantly checked for understanding with built-in exercises. The exercises are auto-corrected and students are given immediate feedback on their performance.

3. Evaluation

Students' perceptions of the use of animations were obtained by administrating surveys and focus-group interviews which provided both qualitative and quantitative data for our study. Table 2 explains the exact animations used in each of the classes over the two stages in the four year period and the evaluation data collected in each class.

Table 2: Types of animations used and the evaluation strategies used in each class

Note: NRS = Nursing; PHA = Pharmacy; CHM = Chinese Medicine; BIO = Human Biology												
Stage of our study	Stage 1								Stage 2			
Academic year	2008–2009				2009–2010				2010–2011		2011–2012	
Discipline	NRS	PHA	CHM	BIO	CHM	PHA	BIO	NRS	CHM	NRS	CHM	NRS
No. of replies	184	25	23	13	24	30	23	145	40	184	34	188
No. of surveys distributed	195	30	31	13	36	38	46	200	42	199	34	202
AP	√	√	√	√	√	√	√	√				
SMC	√	√	√	√	√	√	√	√				
CP					√	√		√				
UK					√			√	√	√	√	√
Survey	√	√	√	√	√	√	√	√	√	√	√	√
Interview					√		√	√				

The survey was consisted of two parts: Likert-scale questions and open-ended questions. A total of 913 students (out of 1066 students, response rate being 86%) replied the surveys over the four years in the twelve different classes.

For the focus-group interviews, an invitation was sent to all students who took the course in the academic year 2009–2010 (Stage 1). Participation was voluntary. A total of 12 students accepted the invitation and three focus-group meetings was held in May and June 2010. They were students from three disciplines: Human Biology (6 students), Chinese Medicine (5 students) and Nursing (1 student). A list of simple interview questions (protocol) was prepared to guide the interviews. They were about students' perceived effectiveness of using animation to learn, choice of animations or text for study, and suggestions for improvements. A list of simple interview questions were prepared for the interview, they were about students' perceived effectiveness of using animation to learn, choice of different learning media, the improvements of the animation(s) they wished, and other opinions. These questions were guiding questions for the interviewers rather than rigid prescribed structure of the interviews. The interview was taken in a natural approach that students were encouraged to comment freely on the use of the four animations for learning the topics, and suggest what could be improved in the animations. The students attended our interview at three different times (Table 3).

Table 3: Interview date, time and participants

	1st interview	2nd interview	3rd interview
Date and time	20 May 2010, 13:00 – 13:25	26 May 2010, 13:40 – 14:05	9 June 2010, 10:40 – 10:50
Participants and their backgrounds	6 students, Chinese Medicine	5 students, Human Biology	1 student, Nursing

4. Findings

4.1 Stages 1 and 2

In the focus-group interviews conducted at the end of Stage 1, students had the opportunity to elaborate on how animations had assisted in their learning. The students in the three groups in general perceived that the strengths of the animations were clear presentations of the topic content, and therefore it would facilitate understanding of the topics. The followings were the summary of their comments and some quotations.

Students mentioned that it would be more explicit to present procedural information, processes that involved many interactions and dynamic changes by animation that involved many steps, such as some periodical changes (the thickness change of the uterus), the movement of ions (in the topic of counter-current in kidney), ion movement in ion channel in the topic of action potential and the topic about how hormones function. Moreover, easier memorisation of content was also the advantage of animation. Students also remarked that graphics in animations were better than book as they were colourful while many images in books were black and white which was difficult to perceive. The following are some quotations:

- "The (dynamic) graphics showed the steps in process clearly, for this aspect they were better than text and the teaching during lesson"
- "It is good to have animations as a supplementary tool for our learning of complicated process in human body such as the mechanism of filtering wastes in blood by kidney. That process involved many steps, components (ions coming in and out), and flows of fluid."
- "Animation is most needed for mechanisms in physiology that are complicated, for example the ion channel in action potential."
- "Some physiology topics involve too many types of hormones and interactions. This was quite confusing. Presenting them with animation will be a good practice"
- "I just partially understood the process of osmolarity change (in the topic of kidney) during lesson but fully understood after I had viewed the animation … Although there were figures in textbook that showed the value changes of osmolarity in kidney, such changes were still difficult to perceive. I just noted they were discrete changes but not trends of changes"

Students also elaborated on what topics had been challenging to them could be good candidates for our future work.

- "It would be better to have animations as a supplementary tool for our learning of complicated process in human body such as the mechanism of filtering wastes in blood by kidney. That process involved many steps, components (ions coming in and out), and flows of fluid."
- "Some physiology topics involve too many types of hormones and interactions. This was quite confusing. Presenting them with animation will be a good practice."

However, although students tend to agree that the graphics in animation looked good, they did not find animations had a strong effect on learning motivation.

- "It was certain that no matter how attractive the animation was, the motivation effect would not be strong, especially when compared with examination. Moreover, good personal mood should be a more important factor for learning than the provision of animations"
- "I think I was a bit interested in the animation, however, I do not think animation would be a major factor for students' interest of learning. I think learning interest is intrinsic"

Lastly, students gave a few short suggestions on the improvements of the animations:

- "Speed to play the animation: all students thought the playing speed was too slow that it needed more time to view, and they suggested making them faster"
- "Add some translations for the difficult terms"
- "Some students suggested adding more topics for animations (e.g. brain, gastro-intestinal tract, endocrine system)"
- "Add exercises in the animations"
- "Animations provided were not informative enough. For example, the explanations of some terms could not be found in animations"

Similar remarks about improvement ideas were also collected in Stage 1 from an open-ended question in the survey. Some of these remarks were:

- To develop more of similar learning tools for other topics as well (mentioned in 10 out of the 62 replies (16.2%) in 2008–2009 and 7 out of the 43 replies (16.3%) in 2009–2010);
- Some students thought the running was slow such as long loading time, slow speed of narration (mentioned in 13 out of the 39 replies (33.3%) in 2008–2009 and 9 out of the 31 replies (29.0%) in 2009–2010);

- Difficult to access/ open the animation (mentioned in 8 out of the 39 replies (20.5%) in 2008–2009 and 1 out of the 31 replies (3.2%) in 2009–2010);
- To provide more references to let students learn more or to facilitate students with less biology knowledge to understand the content (12 out of the 44 replies (27.3%) in 2008–2009; 7 out of the 34 replies (20.6%) in 2009–2010).

Data collected in Stage 1 thus on the whole confirmed the learning benefits of animations. There were also rooms for improvement and some of them were dealt with in Stage 2 (2010–2011 and 2011–2012).

One of the main changes was the addition of extending reading of the topic of the animations. As an example, Figure 2 shows how 'tubular reabsorption' is explained in fuller details on separate pages rather than within the animation.

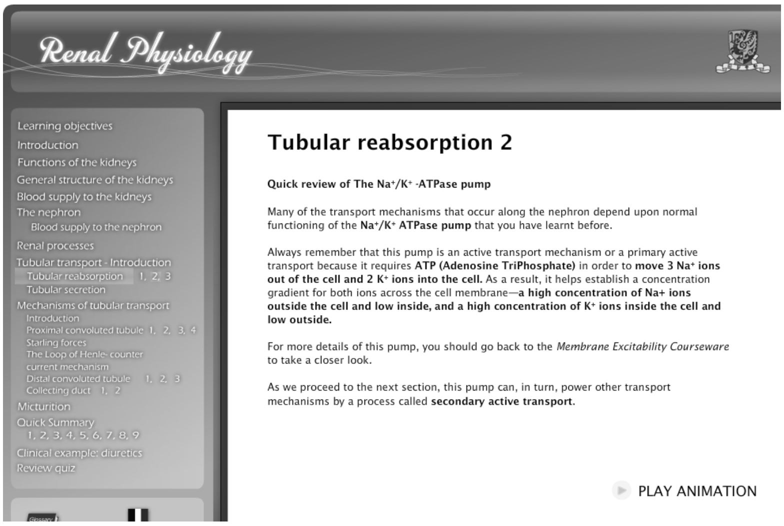

Figure 2: Screen capture of a section page in the modified UK module in Stage 2

The more details added could serve two purposes: to allow students to get a general understanding of topic concepts by skimming through the text first, before they view the animation; and to allow students to learn more in detail after they have viewed the animation.

Captions and explanations appearing together with the animations were still important as they served to foster understanding during the time of viewing the animations. The text, however, was downsized to avoid too much overlapping with the added content. We acknowledged that, as noted by Mayer's (2002), explanations or remarks should be placed next to the image instead of far away from the image. Moreover, results in some empirical studies also echoed Mayer's point. For example, Holsanova, Holmberg and Holmqvist (2009) reported a study carried out with 31 Swedish people as the subjects. The study was to investigate whether different spatial arrangement of text and image would cause different cognitive load. The first setting was that the texts and images placed far away from each other while the second one was with the relevant texts and images placed closed to each other. The results showed that the first setting tended to make readers more difficult to find the correspondences between the texts and the images. In another study by Harter and Ku (2008), 98 sixth-grade American students were randomly assigned learning materials of different spatial arrangements of relevant messages. The result showed that students assigned materials of relevant messages put closed together had higher gains in scores.

4.2 Overall data

The quantitative data collected in the surveys among the two stages (the four academic years from 2008 to 2012) were promising in general. Table 4 shows students' replies in two of the questions that best represent our main objectives in developing the animations: clearer explanation of the concepts and students' better understanding as a result of the additional resources. Students stated how much they agreed to the achievement of these benefits on a 5-point Likert scale Scores, with '1' being strongly disagreed and '5' being strongly agreed.

As you can see from Table 4, students' ratings of many items on the questionnaire approached 4. The perceived learning outcomes of the animations were also to a large extent confirmed: concepts were explained clearly (overall score is at 4.0) and students remarked animation improved their understanding of the various topics (range of overall scores is at 3.9–4.1).

Table 4: Quantitative data of students' perception to the use of animation on learning the physiology topics

Note: NRS = Nursing; PHA = Pharmacy; CHM = Chinese Medicine; BIO = Human Biology													
Stage of our study	Stage 1								Stage 2				**Overall**
Academic year	2008–2009				2009–2010				2010–2011		2011–2012		
Discipline	NRS	PHA	CHM	BIO	CHM	PHA	BIO	NRS	CHM	NRS	CHM	NRS	
No. of replies	184	25	23	13	24	30	23	145	40	184	34	188	913
No. of surveys distributed	195	30	31	13	36	38	46	200	42	199	34	202	1066
Animations explained concepts clearly?	3.9	3.8	4.0	4.1	4.1	3.9	4.1	4.1	4.4	4.1	3.8	4.1	**4.0**
Exercises improved understanding?	3.9	3.9	4.0	4.2	4.2	3.8	3.9	4.0	4.3	4.4	3.9	4.1	**4.0**
Animations improved understanding towards action potential	3.8	3.7	3.8	3.8	4.0	3.9	4.1	4.1	-	-	-	-	**3.9**
Animations improved understanding towards skeletal muscle contraction	3.8	3.5	3.9	3.9	4.0	3.8	4.1	4.0	-	-	-	-	**3.9**
Animations improved understanding towards the intended topics	-	-	-	-	-	-	-	-	4.1	4.1	3.8	4.2	**4.1**

Students' open-ended replies on the surveys also echoed the same positive attitudes towards the animation courseware. For example, students mentioned many advantages of the animations and the key ones were:

- Animations sparked students' interest to learn (mentioned in 11 out of the 48 replies (22.9%) in 2008–2009 and 6 out of the 21 replies (28.6%) in 2009–2010);
- Animations improved students' understanding of concepts (mentioned in 10 out of the 48 replies (20.8%) in 2008–2009, 5 out of the 21 replies (23.8%) in 2009–2010, 15 out of the 73 replies (20.5%) in 2010–2011 and 27 out of the 101 replies (26.7%) in 2011–2012);
- Animations provided clear explanations on the subject matters (mentioned in 16 out of the 121 replies (13.2%) in 2008–2009, 12 out of the 71 replies (16.9%) in 2009–2010, 31 out of the 73 replies (42.5%) in 2010–2011 and 31 out of the 101 replies (30.7%) in 2011–2012);
- Other minor advantages mentioned by students in the two stages included convenience for self-studying the topics, allowing a better efficiency of learning, enabling a self-controlled mode of learning due to the feature of the animation (e.g. can re-play and pause the animation), checking their understanding of the topic and good for revision.

Certainly, there can be some possible improvements in the future, by considering the following comments about the modified version of the animation in Stage 2:

- Some students thought the running was too fast (mentioned in 6 out of the 31 replies (19.4%) in 2010–2011 and 5 out of the 44 replies (11.4%) in 2011–2012);

- The animation was not informative enough, such as explanation to answers, summaries, detailed explanations about the concepts, etc (18 out of the 38 replies (47.4%) in 2010–2011, 6 out of the 44 replies (13.6%) in 2011–2012);
- Not enough function (9 out of the 31 replies (29%) in 2010–2011).

5. Discussion

5.1 Role of animations as learning resources

The feedback collected from students in general confirmed that animations are beneficial to learning. The quantitative data indicated that animations were a good media to explain concepts more clearly, and to improve understanding of the content of topics, as to students' perception. In the quantitative data, students pointed out that animations were particularly helpful in explaining complicated and dynamic concepts which were otherwise difficult to represent through mere text or static images. In addition, some students mentioned that they became more interested in learning, and the animations facilitated memorizing of content.

The advantages of clear presentation of procedural information of animations, however, did not mean that they were superior learning media. When students were asked to take animation or learning materials with static interfaces such as textbook and PowerPoint slides as their first choice of learning medium, students gave different answers. About half of the students selected animation as their first choice of learning medium, while others preferred static media more. The former type of students reasoned that the animations were not informative enough. For example, the explanations of some terms could not be found in animations but could be found in notes or textbooks. If they view animation first, they would not able to understand some terms. They therefore put forward that their comment practices were to read notes first, to get a perception of the topic in brief, then view the animations, and followed by reading books. More topic content was added in the animations in Stage 2 as for improvement.

There had been worries that animations may represent actions in high speed such that perception of the procedural changes in processes can be difficult (Morrison, Tversky, and Betrancourt, 2000). Such worries were not found in our study. It may be because this study is to emphasise on the supplementary function of animations. Animations assist in the descriptions of concepts on the traditional media rather than acting as a replacement for the traditional media. In addition, the animations can be made to be easily plausible and repeatable through controlling the scroll-bar. The interface allows students to pause and think before going on to the next step.

5.2 Design features and improvement

Considering students' feedback on the aspects they liked best and the areas they would like to have improvement, it was summarised the following points for the design and application of animations for more learning benefits.

- Explanations should be rich and clear (translation may be necessary) so that the animations are self-sufficient learning resources.
- There should be a good balance between clear presentation and beautiful interface, enough function and the speed of running/ loading of the animations.
- Animations are better media for certain types of topics: for example, dynamic concepts involving movement of tiny components, or actions that involve complicated interactions different parts. Care is needed to spend effort in the most needed scenarios.

6. Conclusion

In this project, animations were developed as supplementary learning resources for students in a physiology course for challenging and dynamic concepts that are difficult to represent on text and static images. 913 students used all or some of the animations in twelve different classes of the same course over a period of four years (in two stages). Perceptions of students in Stage 1, collected through surveys and focus-group interviews, were positive and demonstrated that animations could explain complicated contents more explicitly to students and there was a great student demand for similar learning tools for other challenging topics in the discipline as well. Our earlier experience tended to show that animations are good supplementary learning materials for students particularly for learning of complicated concepts. Our effort in Stage 2, however, seemed to indicate that animations, with close integration with extended readings, can be good in facilitating learning (e.g. better understanding, sparking students' interest of learning) of the subject matter as well.

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