Creating Teaching Module in PDF with Embedded Animations and Lecture Note

Taeil Yi

***Abstract*—**The use of lecture video and animation has been increased especially for online and distance learning courses. There are two major problem when an online or a multipoint course is offered for the first time. First, producing lecture video and animation is not an easy task for instructors who are going to teach online course first time. Second, most instructors who are novice for producing such teaching modules rely on pre-existing learning resources. In many cases those pre-existing teaching resources are not matching with an individual instructor's course level or pedagogy. This article shows detailed 'how-to' tutorials for mathematics instructors who is novice to produce (1) animation GIFs using GeoGebra, (2) PDFs with embedded animations, and (3) PDFs with embedded 'paper-pencil' style lecture videos with voice using smartpen as instructional tools.

***Keywords*—**Animation in pdf, GeoGebra, LaTex, IrfanView, ShareLaTex, smartpen note

I. Introduction

MANY researches have been done on using animation and lecture videos in teaching. For instance, Milovanovic, et.al. A research [13] shows students learned with multimedia showed better theoretical, practical and visual knowledge, and they were highly interested in learning with multimedia. Another research [23] shows that students learn better with animations since the animation engages them in learning. Akpinar ([1]) found that the interactive animations used as presentation tools were more effective on the students' understanding of course concepts. Aksoy ([2]) also found the similar result that animation is more effective than traditional teaching methods in terms of enhancing students' achievement. In some researches like [10] they found that animation does not improve understanding across all conditions, but students show evidence of higher levels of understanding.

Even though Evans ([6]) found that lecture videos might not be the best tool of instruction for 'introductory' students, a research ([7]) shows that usage patterns affect students' attitudes to video lectures as a learning tool. Halupa ([9]) also found that even the students who were given access to online video lectures perceived course material more positively and felt the additional material was useful, there were no significant differences between students in the target group and the control group. On the other hand, some researchers found that lecture videos will have similar or greater use and value in an online course when live-instruction and discussion are limited ([3]), and students showed improvement after watch visualizations (graphic design, video, and animation) and there was significant improvement in responses between the first and second visualization ([21]).

It is clear that including animations and videos in lecture would be beneficial to students' learning, and providing teaching modules with visualization and animation of better quality are demanded more than ever. Instructors are urged to provide visualized teaching modules for their students. The demand of having the ability to produce such modules according to own pedagogy has increased dramatically in teaching field. One major problem is that most instructors are novice to production of such materials. As stated in a recent study [8] instructors depend on their universities to provide the video capture infrastructure, and should work with the campus information technology personnel to produce lecture videos.

There are some ways to produce such materials with minimal knowledge of media production. In this article, we focus on producing animation GIFs, and embedding such animations and lecture videos into PDF file which is one of best formats for teaching module since it is easy to share and can be viewable in any computer with a PDF reader such as Acrobat Reader. It is known that embedding an animation in a pdf file is impossible without using some high-end commercial programs. However, there is a way to produce PDF with animation (GIF) using LaTex. Some sites such as [30] provide source file (Tex) with the output file (pdf) for creating some animations in pdf/beamer.

Holecek ([11]) describes a new way of creating animations in PDF with a free software pdfTeX only, which requires some skills of Acrobat JavaScript and pdfTeX. It is not easy for a novice instructor.

A post in GeoGebratube shows how to include animated GIF in LaTeX and produce PDF file with animation (see [25]). The post explains the method to animated construction step with LaTex syntax and packages such as Pstrics and PGF/TiKZ which are not popular to most LaTex novices.

Another site [28] shows how to include animation in pdf using LaTeX, especially using movie15 or Media9 packages in LaTex. It also shows some tools (without detail how-to) to create graphic files (such as MPEG) mostly for Mac OS system.

In this article, we demonstrate how produce animated GIF

T. Yi is with the University of Texas Rio Grande Valley, Edinburg, TX 78521 USA (corresponding author to provide phone: 956-665-3535; e-mail: taeil.yi@utrgv.edu).

file using GeoGebra, and then how LaTex together with a free photo editing program such as IrfanView can be used in producing animation embedded in PDF file. We also introduce the desktop software of a smartpen and shows how to convert the note writing file to PDF file with video and audio recording together.

II. Making GIF with GeoGebra

The GeoGebra (GGb) program is the key to produce dynamic graphs for teaching. It makes possible to make an animation and/or a series of graphics quickly and effortlessly.

A. Using a slider

The GeoGebra program makes possible to insert sliders that control dynamic moves within the graphics. For producing animation (especially within a pdf file) from a GGb file, we should include at least one slider in the GGb file. For example, make a line segment using two points, say H and K, after making a slider, say t, with the following condition: Min: 0, Max: 1, Increment: 0.05, Animation Speed: 1, Repeat: Oscillating (see Fig. 1). Then type the following in the input filed on the GGb file:

$$A = (1-t)*H + t*K$$

in order to make the point A on the line segment. The position of the point A depends on the slider value t. We may hide the slider by either (1) right click on the slider and unselect Show Object or (2) place it outside of the animation area, if we do not want to show it inside the animation.

Fig. 1 Setting for a slider in GGb

Then, by the following steps, we will get an animated gif file:

i. Select File > Export > Graphics View as Animated GIF
ii. Select one slider (if there are more than one...), say t
iii. Click Export button (see Fig. 2)

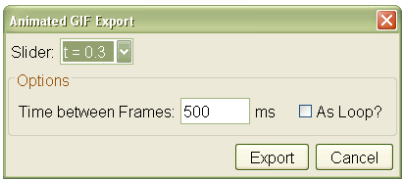


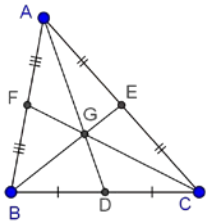
Fig. 2 Exporting a GIF file from GGb

To check the animation, open the gif file with a web browser or with IrFanView program.

B. Using Construction Step with a Slider

One of the excellent features of GGb program is that it comes with the built-in function named 'Construction Step'. In many cases we want to show the entire procedure of the construction of the graphic, not only because instructors want to show the step-by-step construction but also they need to show the same explanation in several different classes most cases. Using the build-in 'Navigation bar' in GGb program we can show the entire construction steps either step-by-step or on play mode. As we saw in *A* above, we have to use a slider for producing animated gif file from GGb. So we need to connect the construction steps and a slider. If we want to show all construction steps, we just to assign a slider to the construction step number. But, in most cases, we want to show specific construction steps only. In such case the connection between a slider and the construction steps should be modifiable, so the animation shows selected construction steps only. Moreover, we do not want to change or update the setting between the slider and the construction steps when we change some construction steps and remove/add some objects.

Inside 'Construction Protocol' window within GGb program we can rearrange the construction steps if necessary, and assign breakpoints for chosen steps only. So we need assign those breakpoint steps to a slider. We will use a construction of the centroid of a triangle to explain this. Let's make a GGb file, titled '*triangle.ggb*', showing the construction of the centroid, named G, of a triangle ABC by finding the intersection of three mediums AD, BE and CF, which requires several line segments to show that points D, E and F are the midpoints of the sides a, b and c. The Figure 3 shows the result triangle and the corresponding construction steps with breakpoints at steps 4, 8, 12, 16 and 17.



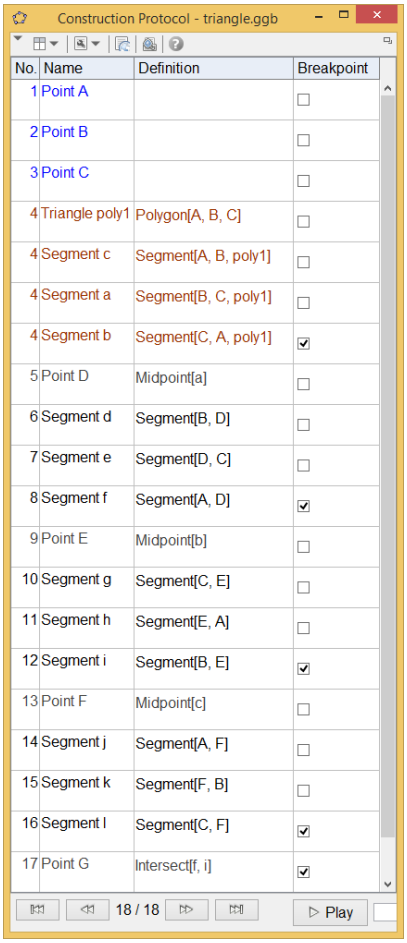


Fig. 3 Construction Protocol Window with the figure

C. *Procedure to Connect Construction Step and Slider*

i. Decide and check 'breakpoints' in the 'Construction Protocol' window (e.g. 4,8,12,16,17 – 5 breakpoints)
ii. Make a list as the following where objects are the one for breakpoints:
mylist={ConstructionStep[b], ConstructionStep[f], ConstructionStep[i], ConstructionStep[l], ConstructionStep[G]}
iii. (Select *Construction Protocol window* > *Options* > *Show Only Breakpoints*)
iv. Make a slider, named 'myslider' (e.g.), with:
Min: 0, Max: 5, Increment: 1, and *Repeat: Increasing*
v. (Select *GGb window* > *Algebra* > *Sort Objects By ...* > *Construction Order*)
vi. Put the code below in *'Advanced* > *Condition to Show Object*' of all the object which needs to be shown for the construction:
ConstructionStep[nameoftheObject]<= Element[mylist,myslider]
vii. Add the following code after the code in step vi above in *'Condition to Show Object*' of the object which needs to be hidden after certain 'breakpoint' step, say q:
&& cs<=q
viii. Select *File* > *Export* > *Graphics View as Animated GIF*
ix. Select the slider *myslider*
x. Click '*Export*' button

Step iii. and v. above are not necessary, but will be helpful.

III. Making PNG Frames with IrfanView

To include animation into pdf file, the animation file (GIF) needs to convert to a series of png frames. One of the best free programs to make such png frames from an animated gif file is IrfanView (see [26]). As an example, we can use the gif file from internet sites (such as [27]), or our own gif file using some programs such as GeoGebra. To retrieve the gif file from an internet site, right click on the first animation and select `Save image as...' After save the file, we may use IrfanView to watch the animation of the original gif file.

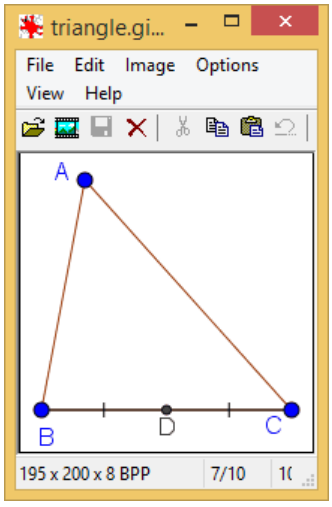


Fig. 4 A GIF in IrfanView

To make the series of png frames from the animated gif file (`*triangle*') follow the steps below:

i. Make a folder, say 'fig'.
ii. Open the gif file with IrfanView. (See Fig. 4)
iii. Select 'Options > Extract all frames...'
iv. Change the `Destination directory:' to the `fig' folder.
v. Select PNG-Portable Network Graphics for `Save As'.
vi. Click `Start'.

The procedure above produces several `frame' files with the same name. For instance, there may be 17 png frames in the `fig' folder, starting from `*triangle_frame_0001*' to `*triangle_frame_0017*'. The number of frames depends on the condition of the original gif file, especially the minimum and maximum frame numbers and the increment. The name of those frame files will be the same as the original gif file name with the extra ending part, such as `*_frame_xxxx*'.

IV. Making PDF with Animation using ShareLaTex Site

To make a pdf file with animation on it we need to create a source (LaTex) file, and add the 'animate' package into the preamble of the source file. Before installing a Tex program and an Tex editor program which requires a lot of time and effort, we recommend using an online LaTex editor service site such as ShareLaTex® (see [29]). It comes with a complete ready to work LaTex environment running on their server with many LaTex source templates. It requires no pre-installation on user's computer, but the user needs to make an account on the server to use the service.

A. *Making a project in ShareLaTex site*

To make a LaTex source file in ShareLaTex site, follow the procedure below:

i. Go to https://www.sharelatex.com/project, make an account, and then log in.
ii. Click 'New Project' at the top left side, and select 'Blank Project'.
iii. Type a name, say 'mytex', for the 'New Project', and then click 'create'.

There will be 3 views in the ShareLaTex page: menu, source view and preview. (See Fig. 5)

B. *Uploading PNG frame files to the ShareLaTex project site*

The fig frame files should be uploaded to the 'mytex' project in the ShareLaTex page as the following:

iv. Click 'New Folder' (the second icon) above the menu side, type a name (say 'fig'), then click 'Create'.
v. Click the 'fig' folder in the menu.
vi. Click 'Upload' (the third icon) above the menu side. The 'Upload File(s)' window will be appeared.
vii. Drag some (up to 40) png frame files from the 'fig' folder, and drop on the 'Upload File(s)' window.
viii. Click the 'fig' folder in the menu again, and do the same 'Drag-Drop' procedure until to finish uploading the entire png frame files.

The ShareLaTex site accepts up to 40 files at the same time for uploading. Hence the step (vii) should be done several times depending on the total number of frames.

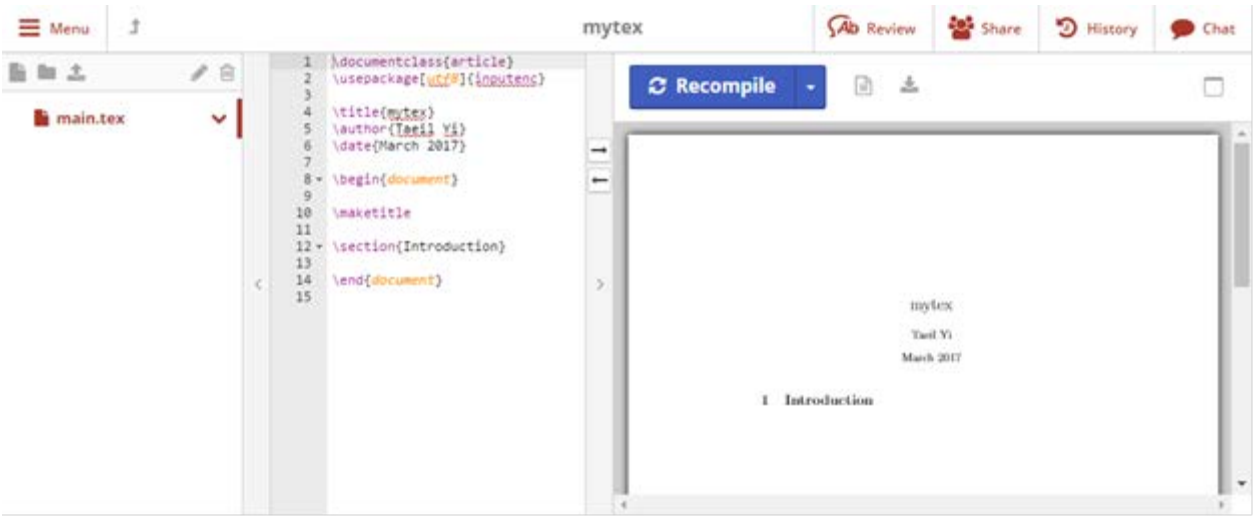


Fig. 5 ShareLaTex Page

C. *Making the PDF with animation*

Replace the entire content in the source view by the following code:

```
\begin{verbatim}
\documentclass[10pt]{article}
\usepackage{animate}
\begin{document}
\animategraphics[autoplay,controls]
{12}{fig/triangle_frame_00}{01}{17}
\end{document}
\end{verbatim}
```

The last number, 17, in the code above should match with the png frame numbers in the 'fig' folder. The folder name, fig, should match with the folder name in the menu. To produce the pdf file, do the following procedure:

ix. Click 'main.tex' on the menu, and then click 'Recompile' above the preview.

x. Click 'download PDF' icon above the preview window, and then open the downloaded pdf file.

The preview window in ShareLaTex does not show the animation. To see the animation the pdf file should be downloaded from ShareLaTex site and open it with a PDF viewer program such as Adobe Acrobat.

For the case of the number of frames is less than 10, say 8 frames only, the code may be written by either

```
\begin{verbatim}
\animategraphics[autoplay,controls]
{12}{fig/triangle_frame_00}{01}{08}
\end{verbatim}
```

or

```
\begin{verbatim}
\animategraphics[autoplay,controls]
{12}{fig/triangle_frame_000}{1}{8}
\end{verbatim}
```

On the other hand, if the number of frames is more than 99, say 153 frames, then the code should be changed as:

```
\begin{verbatim}
\animategraphics[autoplay,controls]
{12}{fig/triangle_frame_0}{001}{008}
\end{verbatim}
```

The ShareLaTex provides lots of templates such as CV, cover letter, presentation, thesis, etc., and they can be chosen after click the 'New Project' at the main page of ShareLaTex. (See Fig. 6)

By using the code *\usepackage{animate}* at the preamble (before *\begin{document}*), the animation can be embedded to any of templates.

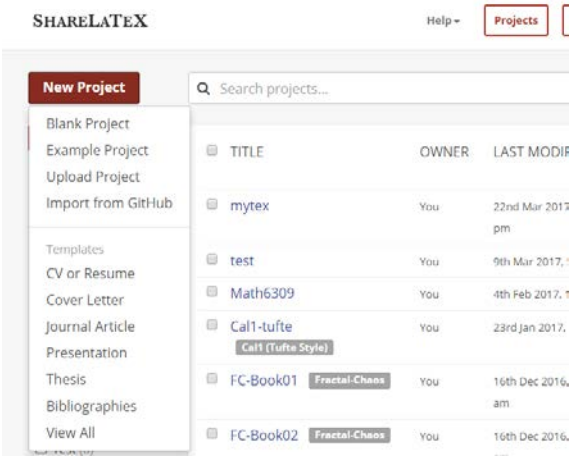


Fig. 6 Templates in ShareLaTex

D. *Options*

We can assign several options (inside the blankets) regarding the animation using the blankets in the code. For instance, *controls* in the option in the code is for insertion of

control buttons below the animation. To change the size of the control buttons, put *buttonsize=<size>* in the option such as

```
\begin{verbatim}
[autoplay, controls, buttonsize=10pt]
\end{verbatim}
```

By default, the control button comes with black. By using *buttonbg=<color>* and *buttonfg=<color>* the control button colors can be changed. By default, control button widgets are drawn with black strokes on transparent background. The background can be turned into a solid color by the *rst* option such as *buttonbg=rst*, while the second option species the stroke color. The parameter is an array of colon-(:)-separated numbers in the range from 0.0 to 1.0. The number of array elements determines the color model in which the color is defined: (1) gray value, (3) RGB, (4) CMYK. For example, '1', '1:0.5:0.2' and '0.5:0.3:0.7:0.1' are valid color specifications such as

```
\begin{verbatim}
Buttonfg=1:0.5:0.2
\end{verbatim}
```

To make the animation loops, put *loop* in the option such as

```
\begin{verbatim}
[loop, autoplay, controls]
\end{verbatim}
```

To scale the size of the animation, use *scale=<factor>* in the option where *<factor>* is between 0 and 1, such as

```
\begin{verbatim}
[autoplay, scale=0.5, controls]
\end{verbatim}
```

Most of this section is from [24], and check out the file for more detail information.

V. Making PDF including Lecture Video with Voice using a Smartpen

For more than a couple of decades many researches on 'designing' a virtual classroom have been done (e.g., [20]). Most of them are targeting on-campus students, and so there is no clear concept about 'virtual' classroom and lecture modules for online courses. Sodha ([18]) claims that the reason for low-impact of lecture notes with web-based textual information and static diagrams on students' learning is the complex human learning process, which demands interaction between a student and the instructor.

Reins ([15]) shows that digital ink technology (such as tablet PCs) is changing the way of students' note taking and instructors' teaching methods. Reins mentioned a recent study [19] showed that the tablet classroom environment is more effective than the traditional format of lectures. We found that smart pens provide a similar environment.

The smart pen (especially Livescribe SmartPen) is designed to help students' notetaking and lecture review. It comes with an internal microphone, a camera and a memory card for saving audio recording and handwriting capture for later review. Many researches have been done on the relation and effectiveness between the use of the smart pen and the students' academic achievements. Sarah, Emily and Christine ([31]) showed that the smart pen helps students with learning disabilities, especially for math classes by offering the ability to look at a problem and hear the teacher's explanation again including a helpful calculator feature.

The Livescribe Smartpen can be used to produce pdf file with embedded lecture videos. The Livescribe Echo smartpen digital voice recorder is a ballpoint pen and comes with a camera (at the tip of the pen) and a voice recorder together. Writing on a digital paper which can be made using a laser printer (600dpi), it records what it writes with synchronized audio which has recorded at the same time. Users can download and install the free smartpen desktop software. The digital copy of notes with video and audio recordings produced by this pen can be replayed and shared through the desktop software. (See Fig. 7)

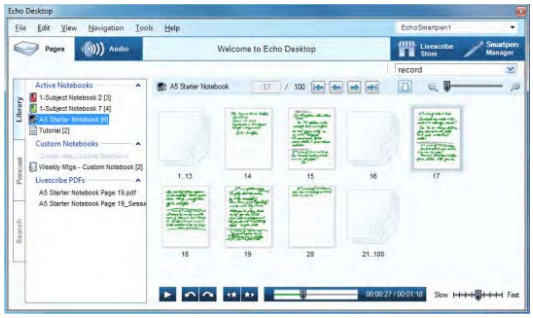


Fig. 7 Smartpen desktop program

One of sharing methods is to export the digital copy of notes to PDF format. The PDF control toolbar is located at the bottom of each page in the PDF file. This toolbar controls playback of recorded handwriting and audio. (See Fig. 8)

There are two ways of search and pick playback of the recording: the slider in the toolbar and 'clicking'. Users can search and play any position in each page by moving the slider in the toolbar or 'click' on the page at which they want to watch. One downside of the produced PDF file is that this PDF file cannot be merged with a regular PDF file unless losing the video and the voice.

VI. Conclusion

It is widely recognized that visualization and animation of lecture contents give better chance students to understand the course content. Teaching materials with video and audio recordings have become the most valuable teaching modules especially for online and distance learning. Many technologies have been developed to help producing such teaching

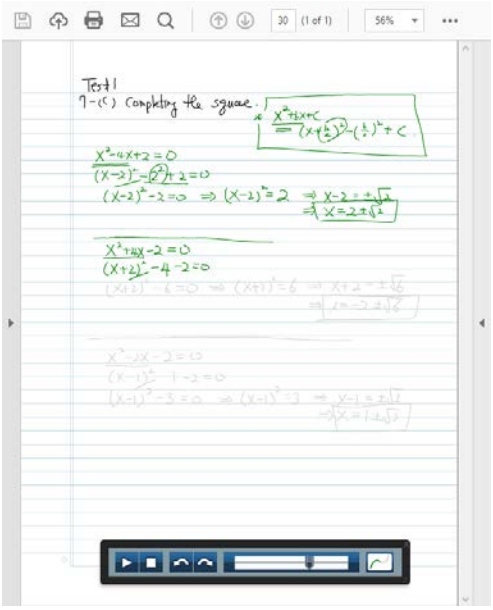


Fig. 8 Playing mode of smartpen note (pdf)

materials. Thus, while instructors are urged to use these visual aids in their teaching, they are also encouraged to produce such material by themselves.

However, producing such teaching materials is not an easy task for instructors. There are needs to find easy way to practice making their own teaching modules. This article provides a couple of examples of producing PDFs with visual contents so that instructors may use them as supporting materials for teaching. It is hoped that easier methods and technology would be developed which come with shorter learning curve, and they would benefit instructors who are novice to such methods. It is also hoped that the suggested methods in this article are not to be taken as ultimate solutions. Rather, it provides a starting point that instructors can use them as a springboard for developing their technology skills for producing better teaching modules.

REFERENCES

[1] E. Akpinar, "The Use of Interactive Computer Animations Based on POE as a Presentation Tool in Primary Science Teaching," *Journal of Science Education and Technology*, vol. 23, no. 4, 2014, pp. 527-537.

[2] G. Aksoy, "The Effects of Animations Technique on the 7th Grade Science and Technology Course," *Creative Education*, vol. 3, no. 3, 2012, pp. 304-308.

[3] D.H. Brecht, "Learning from Online Video Lectures," *Journal of Information Technology Education: Innovations in Practice*, vol. 11, 2012, pp. 227-250.

[4] S. Chandra, "Experiences in Personal Lecture Video Capture," *IEEE Transactions on Learning Technologies*, vol.4, no.3, 2011, pp.261-274.

[5] V. Chieu and P. Herbst, "Effect of an Animated Classroom Story Embedded in Online Discussion on Helping Mathematics Teachers Learn to Notice," *The Journal of the Learning Sciences*, vol. 20, 2011, pp. 589-624.

[6] H. Evans, "An Experimental Investigation of Videotaped Lectures in Online Courses," *TechTrends: Linking Research and Practice to Improve Learning*, vol. 58, no. 3, 2014, pp. 63-70.

[7] M.N. Giannakos, L. Jaccheri, and J. Krogstie, "Exploring the Relationship between Video Lecture Usage Patterns and Students' Attitudes," *British Journal of Educational Technology*, vol. 47, no. 6, 2016, pp. 1259-1275.

[8] T. Grossman, F. Chevalier and R. H. Kazi, "Your Paper Is Dead! Bringing Life to Research Articles with Animated Figures," *Proceedings of the ACM Extended Abstracts on Human Factors in Computing Systems*, 2015, pp.461-470.

[9] C.M. Halupa and B.W. Caldwell, "A Comparison of a Traditional Lecture-Based and Online Supplemental Video and Lecture-Based Approach in an Engineering Statics Class," *International Journal of Higher Education*, vol. 4, no. 1, 2015, pp. 232-240.

[10] D. Harris, *An Examination of the Impact of Computer-Based Animations and Visualization Sequence on Student Understanding of Hadley Cells in Atmospheric Circulation*, ProQuest LLC, Ph.D. Dissertation, University of Maryland, College Park.

[11] J. Holecek and P. Sojka, *Animations in pdfTEX-generated PDF A New Method for Directly Embedding Animation into PDF*, A. Syropoulos et al. (Eds.): TUG 2004, LNCS 3130, 2004, pp. 179–191.

[12] J. Lewin, "Creating Course Material in the Form of On-screen Documents and Videos," *Proceeding of International Conference on Technology in Collegiate Mathematics*, 2008, pp. 158-162.

[13] M. Milovanovic, D. Takaci and A. Milajic, "Multimedia Approach in Teaching Mathematics -- Example of Lesson about the Definite Integral Application for Determining an Area," *International Journal of Mathematical Education in Science and Technology*, vol. 42, no. 2, 2011, pp. 175-187.

[14] D. Nolan and D. Lang, "Dynamic, Interactive Documents for Teaching Statistical Practice," *International Statistical Review*, vol. 75, no.3, 2007, pp. 295-321.

[15] K. Reins, "Digital tablet PCs as new technologies of writing and learning: A survey of perceptions of digital ink technology," *Contemporary Issues in Technology and Teacher Education*, vol.7, no.3, 2007, pp. 158-177.

[16] W. Roth and G. Bowen, "When are Graphs Worth Ten Thousand Words? An Expert-Expert Study," *Cognition and Instruction*, vol. 21, No. 4, 2003, pp. 429-473.

[17] A. Sadik, "Students' Preferences for Types of Video Lectures: Lecture Capture vs. Screencasting Recordings," *Journal of Educational Multimedia and Hypermedia*, vol. 25, No. 2, 2016, pp. 189-208.

[18] J. Sodha, "Developing Interactive lecture notes," *Proceedings of WebNet World Conference on the WWW and Internet*, 1999, pp. 1420-1421.

[19] J. Tutty and B. White, "Tablet classroom interactions," *Conferences in Research in Practice in Information Technology, Eighth Australasian Computing Education Conference*, vol. 52, 2006, pp. 229-233.

[20] M. Turoff, "Designing a virtual classroom," *International Journal of Educational Telecommunications*, vol.1, no.2/3, 1995, pp.245-262.

[21] A. Velazquez-Marcano, V.M. Williamson, G. Ashkenazi, et. al., "The Use of Video Demonstrations and Particulate Animation in General Chemistry," *Journal of Science Education and Technology*, vol. 13, no. 3, 2004, pp. 315-323.

[22] P. Wouters, F. Paas and J. Merrienboer, "How to Optimize Learning from Animated Models: A Review of Guidelines Based on Cognitive Load," *Review of Educational Research*, vol. 78, No. 3, 2008, pp. 645-675.

[23] M. Zanin, "Tips, Tricks & Techniques: Creating & Teaching with Simple Animation: Making Biology Instruction come Alive," *American Biology Teacher*, vol. 77, no. 6, 2015, pp. 463-468.

[24] A. Grahn, *The animate Package*, Available: http://mirror.unl.edu/ctan/macros/latex/contrib/- animate/animate.pdf

[25] *How to include animated GIF in LaTeX/PDF*, Available: https://help.geogebra.org/topic/how-to-include-animated-gif-in-latex-pdf

[26] *IrfanView*, Available: http://www.irfanview.net/

[27] *Making_love_heart_01*, Available: http://benice-equation.blogspot.com/2012/02/makin g-love.html

[28] J. Nockel, *PDF with animations*, Available: http://pages.uoregon.edu/noeckel/PDFmovie.html

[29] *ShareLaTex*, Available: https://www. sharelatex.com/project

[30] *Using Tikz in TeX You can use Tikz/pgfplots for creating animations in beamer*. Available: http:// www.texample.net/tikz/examples/tag/animations/

[31] Sarah Williams, Emily Johnson, Christine Bouck, (2010), Livescribe Pulse SmartPen: Reflections of College Students with Learning Disabilities After Use of this Assistive Technology, Project STEPP, East

Carolina University, Available: https://www.ahead.org/uploads/conference/2010/Poster%20Session%202/PS2_Livescribe%20Poster.pdf

Taeil Yi was born Seoul, South Korea on Dec. 16, 1962. He received a Ph.D. in mathematics and M.Ed. in mathematics education from University of Florida, Gainesville, FL, USA 2000.

He is a Professor at the University of Texas Rio Grande Valley, Edinburg, TX 78521. He has published several articles in mathematics and mathematics education. His research interests are Teaching with Technology, biomathematics, and graph theory.

Dr. Yi is a member of MSA and MAA. His biography lists in Who'sWho in the World, Who'sWho in America, etc.