Crafting Technology-Enhanced Educational Videos for Visual Learners

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ABSTRACT

This paper discusses aspects of my teaching practice, how my students perceive it, and my reflections on it. The discussion is meant to allow cross-disciplinary educators to consider adopting or adapting from my approach. Students entering the CS or Software Engineering discipline have limited prior exposure to the taught subjects. What exacerbates their learning difficulty is the class size, restricting instructor's intentional pauses and interactions. Furthermore, there is often a gap between the theoretical insights covered in lectures and the technical pre-requisites for completing the experiential laboratory assignments. My belief in *inclusive* teaching has led me to support student learning and engagement through an integrated use of: **1)** a drawing tablet, replacing the conventional, in-class whiteboard and mirrored to the computer desktop, for illustrating concepts and examples; **2)** *choreography* of computer desktop activities, e.g., slide presentation, illustrations on the drawing tablet and programming IDEs; and **3)** recordings accessible outside the classroom for students' self-paced learning and review. I have acquired my experience and expertise from recording 500+ lectures and 150+ hours of tutorials, where the *unifying* theme is the constant and frequent use of the drawing tablet for building illustrations, from scratch, of abstract concepts and/or complex examples. In all videos, the same level of clarity, quality of presentation, and proficiency of *choreographing* visual annotations is maintained. As a voluntary service to my community, I designed and have been running a course designed to share my teaching experience and reflections with fellow instructors across academic disciplines.

KEYWORDS

Large Class; Educational Videos; Remote Instructions; Instructional Technologies; Drawing Tablet; Inclusive Teaching

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1 INTRODUCTION

My teaching journey started in Fall 2015, when I joined the global campus of the State University of New York (SUNY), Korea [15], where small classes permitted my attention to the individual learning processes of my students. In Fall 2017, I rejoined my alma mater and have taught large classes (e.g., 400+ students for first-year courses, 150+ students for second-year and third-year courses) in my home department. The shift from small, intimate classes to larger groups has required further developments in my teaching methods.

Having taught 2,700+ Engineering and Computer Science students, in courses ranging from the first to the fourth years, I am committed to ensuring, as far as possible, that the quality of my delivery of learning opportunities is consistent with that of teaching small classes. I want students in my large classes to know that their professor cares for their learning process, no less than students in my smaller classes.

My approach to conducting lectures and creating tutorials is innovative and effective, as recognized by the international community of computing education [9, 10]. Prior to the current pandemic, and even during the difficult time where courses were delivered remotely, my teaching practice comprising **1)** intensive use of a drawing tablet; **2)** design of starter pages (e.g., Figure 2a on page 4, a gallery of starter pages [5]); **3)** systematic and substantial visual annotations for illustrations; and **4)** open-access video sharing has been *unique* across my home university. Moreover, compared with other universities (e.g., MIT [13] and Stanford [17]) which also make lecture recordings accesible by the public, I attribute the novelty of my teaching practice to the intensive use of a drawing tablet for both synchronous and asynchronous deliveries.

My approach also contributes towards *inclusive* teaching [1], aiming at maintaining a learning environment facilitating students with *diverse* (e.g., cultural, language) backgrounds, learning modalities/styles, and cognitive abilities to grow intellectually. More specifically, my approach provides students with both clarity (via a drawing tablet for content deliveries) and flexibility (via lecture/tutorial recordings that persist beyond scheduled, live classes). Moreover, my classes *include* not only students who are enrolled, but also, thanks to their open-access nature, all interested learners across and outside my university community. Anecdotally, my students recommended these videos to their fellow students, or even made use of these videos for their subsequent study or work endeavour.

To help readers understand my approach, I will describe the teaching context and challenges (Section 2), summarize the modes of delivery I have experienced (Section 3), discuss reflections on how my approach supports the student learning (Section 4), and detail the technical setup of my approach (Section 5).

Furthermore, I will report two major updates on my practice:

(1) My approach has been adopted, *seamlessly*, in the design and delivery of remote courses between Winter 2020 and Winter 2022. I will report how students perceive my online delivery (Section 6) and my reflections (Section 7).
(2) In Summer 2021, I proposed, designed, and have delivered instances of a new course that is meant to transfer my proven teaching approach (based on [9, 10]) to colleagues in various academic disciplines across the university, and potentially to those interested across the globe. I will discuss the design of the course and how participants perceive it (Section 8).

2 TEACHING CONTEXT AND CHALLENGES

It is challenging to teach complex computational thinking [19] (e.g., arrays, loops, object-oriented thinking, algorithms on recursive data structures) and software design principles (e.g., design by contract, object-oriented design patterns leveraging polymorphism and dynamic binding) in undergraduate courses. More precisely, students entering my discipline are faced with two major learning challenges:

(1) Comprehension of taught subjects, such as complex computational thinking, is potentially limited because students have limited exposure to them. What exacerbates the learning difficulty is the class size (e.g., 400+ students for 1st-year courses, 150+ students for upper-year courses), restricting instructor's intentional pauses and student interactions, and students are occupied by copying (often blindly) the instructor's remarks and board notes. I believe that such remarks and notes reflect the instructor's insights into the taught subjects and are thus a valuable aid for student learning.
(2) There is often a gap between the theoretical insights covered in lectures and the technical pre-requisites for completing the practical, experiential laboratory assignments. In other words, one may not expect students attending lectures to be prepared for practical sessions. Such a gap exists due to lecture hours being fixed and limited, making it infeasible, in scheduled classes, to accommodate complete, in-depth discussion and illustrations of certain technical skills.

Moreover, my students are vastly *visual learners*: they understand (and thus stay motivated and remember) more effectively via visualizations of the subject matter, presented in gradual and detailed steps; and they struggle with learning through a mere slide show (which is "visual" but not effective in attracting engagement).

To address the above two learning challenges, I adopted my approach (Section 4) in all undergraduate CS and Engineering courses I taught between Fall 2017 and Winter 2022. Examples of course topics are summarized below.

- *CS1A Mobile Computing* and *CS1B OOP: From Sensors To Actuators* are the second-semester courses for, respectively, CS and Engineering[1] students at the first year. There are 400+ students enrolled in each of the two courses. In both CS1A and CS1B, students learn about basic computational thinking and object orientation, but through different means. In CS1A, students develop Android mobile apps using the Android Studio IDE (Integrated Development Environment), and visualize the effects of their Java programs on physical tablets. In CS1B, students use Phidget interface boards connected to hardware equipment such as an LED light bulb and Theremin glove. Example topics covered in both courses are: **1)** elementary programming (variables, data types, assignments); **2)** conditionals; **3)** loops; **4)** primitive 1D/2D arrays; and **5)** object orientation (attributes, methods, classes, and class associations).
- *CS2 Advanced Object Oriented Programming* (with 150+ students) is the first course which CS, CE, and SE students study at the second year. Students in CS2 are required to develop, test, and debug Java programs in the Eclipse IDE. Example topics covered in CS2 are: **1)** unit testing; **2)** code reuse and subtyping via inheritance; **3)** polymorphic assignments and dynamic binding; **4)** recursion; and **5)** asymptotic upper bounds (i.e., the big-O notation) of programs.
- *CS3 Software Design* (with 150+ students) is a required course for third-year CS and Software Engineering students. Example topics covered in CS3 are: **1)** the Design-by-Contract (DbC) method for constructing object-oriented software (using loop invariants and variants, method preconditions and postconditions, and class invariants); **2)** the information hiding design principle (exemplified by the Iterator design pattern); **3)** object-oriented design patterns leveraging polymorphism and dynamic binding (e.g., state, composite, visitor, observer); and **4)** introduction to program verification.
- *CS4 Compilers and Interpreters* (with about 20 students) is an elective course for fourth-year CS students. Students in CS4 acquire the skills of: **1)** designing the grammar of a domain-specific programming language; **2)** implementing, with the aid of a parser generator, a compiler for performing semantic operations (e.g., type-checking, formal verification); **3)** testing the input-output behaviour of the compiler; and **4)** producing a detailed user manual.

[1]The majority of students in CS1B are from Computer Engineering (CE) and Software Engineering (SE), whereas others are from Mechanical Engineering and Civil Engineering

3 MODES OF CONTENT DELIVERY

Table 1 (p 3) summarizes my experience on the various combinations of content delivery modes, which are characterized by two orthogonal dimensions: pace (synchronous vs. asynchronous) and venue (virtual vs. in-person).

- Prior to the global pandemic in March 2020, I delivered in-person, synchronous (live) lectures, which were recorded for students to review (or to catch up with missing classes).
- Between the last one-third of Winter 2020 and Winter 2022, due to the campus lockdown, on the one hand, live lectures were replaced by virtual, asynchronous (pre-recorded) lecture videos for studnets to study at their own pace; on the other hand, I still offered the option of virtual, synchronous (Zoom) Q & A sessions for students to ask questions related to the released lecture videos. Due to their optional nature, the attendance to Q & A sessions, compared with that to in-person lectures, were much lower, but they served as the rare opportunities to engage students in real-time.

Modes of Delivery \ Semester	F17	W18	F18	W19	F19	W20	F20	W21	F21	W22	F22
In-Person, Synchronous (Live Lectures)	✓	✓	✓	✓	✓	✓	×	×	×	×	✓
Virtual, Synchronous (Zoom Q & A)	×	×	×	×	×	×	✓	✓	✓	✓	✓
Virtual, Asynchronous (Pre-Recorded Lectures)	×	×	×	×	×	×	✓	✓	✓	✓	×
Asynchronous (Tutorial Videos)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 1: Modes of Delivery: In-Person vs. Virtual, Synchronous vs. Asynchronous

- It is worth emphasizing that asynchronous (pre-recorded) tutorial videos, for both in-person and virtual deliveries, have been used to complement the (synchronous and asynchronous) lecture component.
- As the campus has been fully reopened since Fall 2022, I have been running courses like how I did before the lockdown: in-person, synchronous lectures and virtual, asynchronous tutorials. Thanks to the training from managing online courses, I am able to add virtual, synchronous Q & A sessions as I see helpful for my students (or as they find the need), which were not an option before the pandemic.

4 HOW I SUPPORT STUDENT LEARNING

I believe that learning consists of both understanding and remembering [12]. My students, despite having different cognitive abilities to receive and comprehend new information, *understand* the most effectively when I: **1)** convey the subject matter in the clearest and most complete manner possible; and **2)** control the flow of each class with *flexibility* according to its *dynamics* (i.e., how well students in that particular class receive, or react to, the materials being taught, and to what extent they need extra, tailored clarifications and/or examples). When delivering the course content, my guiding principles are: to be thorough and precise on details using concrete, complete examples; and to be clear on the big picture by telling students an engaging yet logical story connecting bits and pieces.

Equally important is my awareness of the *Ebbinghaus forgetting curve* [3] suggesting the human brain's natural tendency to forget what it does not constantly review and practice. Therefore, completing practical, experiential lab assignments, facilitated by a variety of *technology-enhanced* resources tailored for their *self-paced* learning, is effective for students to recall, reinforce, and eventually *remember* their understanding.

In tackling both learning challenges (Section 2), my belief in *inclusive* teaching has led my to support my students' learning and engagement through an adaptation of a flipped classroom in which:

- I present subjects with the sole focus on in-depth remarks and illustrations of complex concepts and examples; and
- I create lecture and tutorial videos accessible outside the classroom for students' self-paced learning and review.

To achieve this, as visualized in Figure 1, I have adopted the integrated use of:

- *A drawing tablet*, replacing the conventional, in-class whiteboard and mirrored to the computer desktop, for illustrating concepts and examples (which is effective since my students are vastly visual learners who struggle with learning new ideas from a mere slide show);

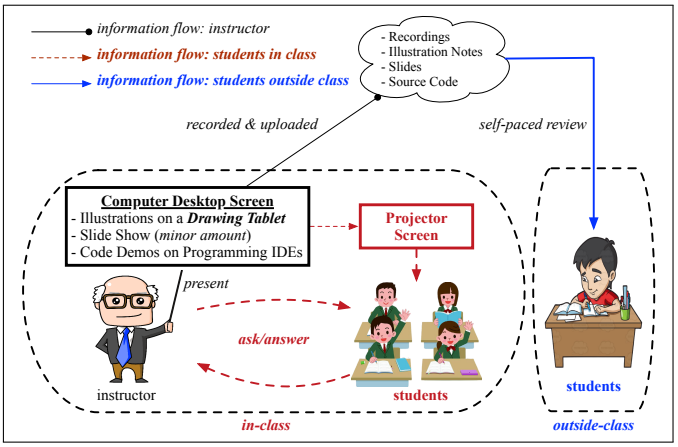


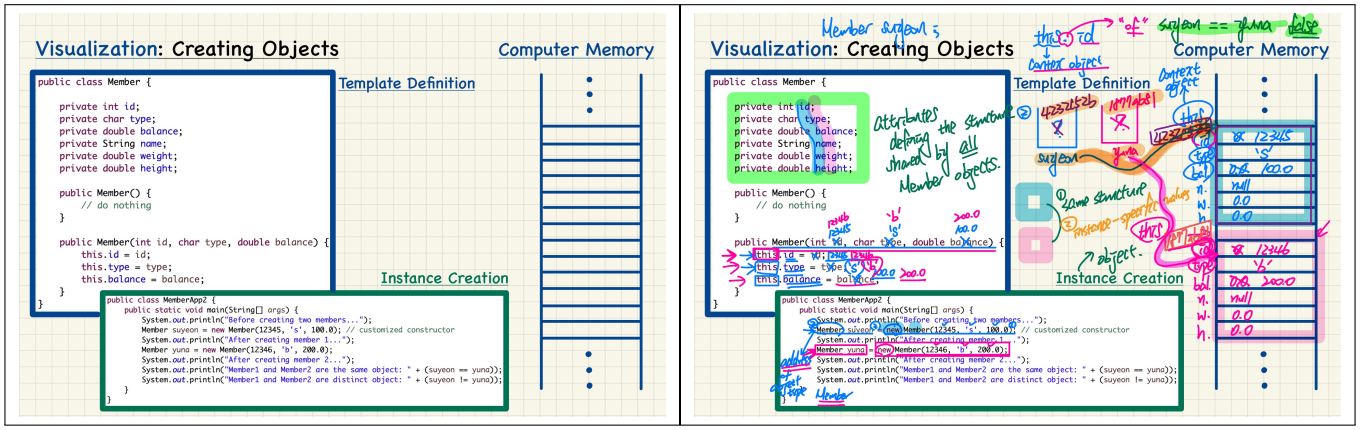
Figure 1: Inclusive Learning via Tech.-Enhanced Delivery

- A program for recording all computer desktop activities, e.g., slide presentation, illustrations on the drawing tablet and programming IDEs; and
- Open access to recordings, by capitalizing on the popularity of the YouTube video-sharing platform [7].

In addressing the first learning challenge of maximizing subject comprehension, I adopt the necessary technologies and equipments to create quality lecture videos for students to review. Specifically, I wear a wireless microphone for in-person, *synchronous* lectures, allowing me to constantly walk around the lecture hall to interact with students, without compromising the recorded sound quality, whereas in remote, *asynchronous* lectures, I use a studio microphone. To date, I have recorded **500+ lectures** [6] for my students' self-paced learning. Moreover, in *synchronous* lectures, my practice of illustrating using a drawing tablet allows me to, while *unfolding* details, adjust my pace and thoroughness according to the *dynamics* of each class (e.g., how the current class is understanding).

In addressing the second learning challenge of preparing students for practical sessions, I have created **150+ hours of tutorial videos** [8] to supplement the lectures and help my students complete labs. For example, in the first-year courses on object-oriented programming, in the lectures I cover the theoretical knowledge on program structures and object orientation, whereas in the weekly, self-paced tutorials I help students acquire the practical experience of constructing complete programs.

The unifying theme in the lecture and tutorial videos I have created is the *constant* and *frequent* use of a drawing tablet for



(a) Before Annotations (00:00:57 ; Click to Zoom In) (b) After Annotations (00:27:22 ; Click to Zoom In)

Figure 2: Visual Illustrations on a Drawing Tablet (See: https://youtu.be/rABPjbnAiks)

building illustrations, from scratch, of complex concepts or examples. Thanks to the recording, students can still engage with the visual illustrations *outside* class by reviewing them at their own pace. I discover, formally and anecdotally, that recordings of these illustrations make my teaching *inclusive of diversity* by accommodating students with different learning styles.

To accurately understand and experience what it is like to learn in my class, I invite readers to watch a tutorial video, linked from Figure 2, created for the remote delivery of *CS1A Mobile Computing* in Winter 2021. Figure 2 shows the illustration process, beginning with a *starter* page (Figure 2a) and progressing to a page with *annotations* on code and diagrams (Figure 2b). Specifically, the session is *choreographed* through constant switches between the drawing tablet (for visual annotations) and the Eclipse programming tool (for running experiments). This was recorded and can be reviewed by students whenever they need. In all of my lecture and tutorial videos, I have endeavoured to maintain the same level of clarity, quality of presentation, and proficiency of choreographing visual annotations (e.g., a gallery of starter/annotated pages [5]).

Furthermore, I am always attending to the balance between learning processes and learning outcomes. My philosophy of lesson planning is that class activities (e.g., lectures, tutorials, experiential labs) are designed *backwards* focusing on the understanding and remembering processes which can most plausibly foster the intended learning outcomes. To implement the *backward* lesson planning [18], each example I illustrate is designed to achieve some *Course Learning Outcome* (CLO). For example, a common CLO among all my courses is to reason about the behaviour of software programs. Accordingly, in my lectures and tutorials, I repeatedly *visualize* the tracing of example programs, line by line, like in Figure 2.

5 ADOPTING MY APPROACH

Here is a summary of the critical steps for assembling the equipment to implement my approach (for a schematic, visual summary, see [9]) for all modes of delivery (Section 3):

(1) Install the following software programs on your teaching computer (e.g., a Macbook Pro): **1)** a presentation program (e.g., a PDF or PowerPoint reader) for your slides; **2)** a learning tool as applicable to your course (e.g., programming IDE Android Studio or Eclipse); **3)** a screen recording program (e.g., Active Presenter) for recording all desktop activities on the computer; and **4)** a program for mirroring the screen of your drawing tablet (e.g., the free QuickTime Player).
(2) Connect the following hardware to your computer: **1)** a wireless microphone, e.g., [4, 20], (for in-person lectures) or a high-end studio microphone, e.g., Blue Yeti [2] (for virtual lectures and tutorials) using a USB cable; and **2)** a drawing tablet (e.g., iPad Pro) installed with a note-taking app (e.g., Goodnotes5 [16]). For **2)**, a wired connection to the USB port is recommended for *stability* throughout the recording session. To mirror the screen of the drawing tablet to your computer desktop, if you use an iPad and a MacOS device, then launch the QuickTime player, start a "New Movie Recording" and select your iPad as the camera.
(3) When ready to begin your lecture/tutorial recording, launch the screen recording program (e.g., [14]) and choose the connected microphone as the input device. My experience has shown that a small amount of *basic* editing is useful: **1)** add a title page (with the instructor's information, topics, *etc.*); and **2)** combine parts of recordings into an integral unit. As I become more experienced in preparing the starter pages and recording long sessions, item **2)** occurs less often as I need not stop because of errors or imperfections on the explanations or illustrations.
(4) When a recording session is finished, stop the screen recording, export it to an acceptable form (e.g., MP4), upload it to an online sharing platform (e.g., YouTube), and share the link with students. Moreover, the note-taking app on your drawing tablet should support annotated pages (e.g., Figure 2b, p 4) being exported as a PDF file.

6 STUDENT PERCEPTIONS

My approach has been reported to have a positive effect on student performance prior to the current pandemic (see [9, 10]).

For online deliveries, Figure 3 summarizes the numerical data of formal student evaluations of my online courses, all with high response rates.

Q1: The instructor conveyed the subject matter in a clear and well-organized manner.
Q2: The instructor made students feel welcome to seek help/advice inside/outside of class.
Q3: The instructor helped me understand the importance/significance of the course content.
Q4: The course learning outcomes were clearly stated and achieved in the course.
Q5: The course helped me grow intellectually.
Q6: Overall, the instructor was an effective teacher in this course.

Course	Term	Responses		Q1	Q2	Q3	Q4	Q5	Q6
CS1A	W21	63.87% (198/310)	Positive (%)	91.54	88.06	86.07	89.55	81.09	84.58
			Strongly Agree (%)	46.77	54.73	40.3	36.82	33.33	41.29
			(Somewhat) Agree (%)	44.78	33.33	45.77	52.74	47.76	43.28
			Mean	6.09	6.19	5.8	5.92	5.56	5.81
			Median	7	7	6	6	6	6
			Dept. Mean	5.72	5.87	5.62	5.74	5.53	5.66
			Faculty Mean	5.79	5.92	5.71	5.82	5.6	5.74
CS3	F20	80.50% (227/282)	Positive (%)	88.07	91.7	76.76	81.74	68.46	75.1
			Strongly Agree (%)	51.85	63.49	42.32	36.51	35.68	44.4
			(Somewhat) Agree (%)	36.21	28.22	34.44	45.23	32.78	30.71
			Mean	6.05	6.35	5.51	5.61	4.99	5.56
			Median	7	7	6	6	6	6
			Dept. Mean	5.74	5.83	5.56	5.73	5.49	5.64
			Faculty Mean	5.69	5.81	5.56	5.75	5.48	5.81
	W20	87.13% (88/101)	Positive (%)	88.83	92.86	87.76	78.36	54.09	89.79
			Strongly Agree (%)	55.1	69.39	44.9	27.84	21.43	56.12
			(Somewhat) Agree (%)	33.73	23.47	42.86	50.52	32.66	33.67
			Mean	6.16	6.38	5.84	5.36	4.4	6.09
			Median	7	7	6	6	5	7
			Dept. Mean	5.66	5.91	5.57	5.58	5.37	5.58
			Faculty Mean	5.71	5.92	5.64	5.58	5.4	5.63
CS4	W20	95.00% (19/20)	Positive (%)	100	100	100	89.47	89.48	94.73
			Strongly Agree (%)	89.47	100	68.42	36.84	63.16	68.42
			(Somewhat) Agree (%)	10.53	0	31.58	52.63	26.32	26.31
			Mean	6.89	7	6.58	5.89	6.37	6.37
			Median	7	7	7	6	7	7
			Dept. Mean	5.66	5.91	5.57	5.48	5.37	5.58
			Faculty Mean	5.71	5.92	5.64	5.58	5.4	5.63

Figure 3: Student Evaluation of Online Courses

The data table shows the percentage of responses that strongly agree, agree, or somewhat agree (i.e., that are **positive**), and the breakdown within this group of the percentage who **strongly agree** and the percentage who **agree or somewhat agree**. The mean and median are also included along with the Departmental and Faculty means. A mean is marked in green if it is strictly above the Departmental and Faculty means.

Moreover, due to the campus lockdown, I started conducting (anonymous & online) midterm course surveys to explore how my students' learning experience was like. One of the survey questions is directly related to my approach discussed in this paper:

I find the instructor's frequent usage of visual annotations (by drawing using his iPad) particularly helpful for my learning, when the course is delivered entirely online.

Results of the above survey question indicate that the vast majority of the students found my approach effective for their learning:

Course	Term	Response Rate	Positive	Strongly Agree
CS3	Fall'20	76% (276/363)	90%	52%
CS1A	Winter'21	60% (215/357)	91%	50%
CS2	Fall'21	76% (246/322)	87%	40%

Table 2: Midterm Surveys on the Use of a Drawing Tablet

Finally, the following selected comments from the (mid-term and end-of-term) course evaluations elaborate on what is indicated in the above survey results:

- "*Depth and quality, of all the [lecture and tutorial] videos are great*"
- "*I believe the videos and annotations on the ipad are really good in terms of digesting the material. He is pretty thorough in the videos and annotations provided ...*"
- "*The way the online class is setup and organized is miles above any other online class I've taken thus far. Lots of information, easy to navigate, active course forum etc.*"
- "*The course resources (lecture, slides, tutorial) were high in quality with clear evidence of tailoring. They were clearly fine tuned and adjusted for the best learning experience.*"
- "*The instructor did his very best with pre-recorded online lectures as well as Q&A sessions throughout the week. No question was unanswered, no idea insignificant. The instructor is amazing and the very embodiment of how a university professor should be be. He is a great teacher knowing and applying all the current and relevant teaching methods in his practice. Instructor went above and beyond of what is required of him, staying way over-time in his office hours, adding so many additional Q&A project sessions and useful resources. ...*"
- "*The instructor was the best I could have got in any course. Jackie has taught us all the concepts with analogy and motivation ... He went beyond the regular hours to help students and I really appreciate his passion ...*"

7 REFLECTIONS

Styles of Presentation. By using a drawing tablet, I have been able to teach more effectively by creating starter pages, and then gradually adding annotations as illustrated between Figure 2a (p 4) and Figure 2b. This is essentially a *dynamic* way for controlling the pace and level of details that the instructor judges as appropriate, with respect to how the current class is understanding the materials. Furthermore, the ability to draw and annotate with the various colours (e.g., red-underline a line of code, colour a portion of drawing) helps the instructor communicate key points to students.

On the other hand, other common styles of presentation have their limitations on engaging students (particularly those who are visual learners):

- *Slides with bullet points and/or figures revealed all at once (with no animation).* Students can easily get lost and demotivated.
- *Slides with well-planed, animated texts and figures.* The fixed order of animations cannot respond well to the class dynamics (e.g., questions not addressed in detail on the planned slides). Also, animated slides are arguably ineffective for walking through complex examples and case studies, as they do not simulate accurately how one would solve problems in assignments and/or test; instead, students would appreciate solving them together with the instructor from scratch.
- *(Animated) Slides with Occasional, Lightweight Annotations.* Compared with dedicated starter pages, minimal and causal annotations may just result in: annotations that are scattered around the slides; and incomplete walkthrough on how problems are supposed to be solved from scratch.

Efforts Demanded from Instructor. My approach relies heavily on my determination on dedicating time and efforts to: **1)** planing what concepts/examples they will illustrate in each tutorial video in the same series; **2)** creating all necessary starter pages on the drawing tablet accordingly; and **3)** choreographing a logical interleaving between various explanations and/or illustrations (e.g., on a programming IDE, on the drawing tablet, on a slide show). Though being a firm believer on this approach, I can expect and appreciate the resistance: the required careful planning may be considered as unaffordable, or even unnecessary, by fellow instructors whose priorities happen not to include teaching, or who have a heavy teaching load.

Student Engagement in Online Deliveries. When my approach was adopted for online deliveries (Section 3), as the lecture videos were pre-recorded, despite their qualities (i.e., clarity and completness), my students' learning effectiveness was still constantly compromised by procrastination (partly due to the heavy workload demanded from other courses). This is why I think holding regular, optional, live Q & A sessions over Zoom, despite its low attendance, remains an important means for engaging my students. More effective ways of student engagement are needed.

8 PROMOTING MY APPROACH TO CROSS-DISCIPLINARY INSTRUCTORS

I believe that my approach should not be restricted to CS or Engineering: instructors across academic disciplines who have the need to illustrate abstract concepts and/or explain details embedded in sophisticated examples would benefit from my approach. In Summer 21, endorsed by my home university's Teaching Commons, I proposed, designed, and have delivered instances of a new course "*Using a Drawing Tablet to Craft Educational Videos for Visual Learners*" [11].

This course transfers my proven teaching methods (based on [9, 10]) to, and shares my own reflections with, colleagues across academic disciplines (e.g., philosophy, mathematics, policy, chemistry, French studies, natural science, theatre, education). Specifically, this course is designed with four two-hour synchronous sessions (which take place in consecutive days or weeks). Each session is conducted by interleaving short lectures, tutorials, and presentation/feedback on three (asynchronous) practicals. The practicals are designed to allow participants to exercise the entire workflow of designing reusable and extensible starter pages, presenting on a drawing tablet, recording lessons, and publishing instructional videos. The initial three deliveries of this course (in August, October, and November 2021) received unanimously high praise from participants, and it is planned to be delivered on a regular basis throughout the subsequent academic years.

Each course instance targets up to five participants to achieve the following Course Learning Outcomes (CLOs):

(**CLO1**) Identify limitations of slide show w.r.t. class *dynamics*.
(**CLO2**) Design starter pages for visual illustrations based.
(**CLO3**) Create reusable starter pages in a note-taking app.
(**CLO4**) Perform annotations on starter pages in a note-taking app.
(**CLO5**) Choreograph slide show and visual illustration.
(**CLO6**) Record, edit, and publish educational videos.

Emphasis on Crafting Starter Pages. The order in which the above CLOs are arranged also corresponds the stages of progression in adopting my approach: Preparation (CLO2, CLO3), Setup & Delivery (CLO4, CLO5), and Sharing (CLO6). My experience thus far confirms that:

- Preparation is doubtlessly the most time consuming, yet most critical, stage that will determine the success of the ultimate content delivery. At this stage, one has to: **1)** clarify themselves as to what examples and/or concepts need to be illustrated (visually) in detail; and **2)** design, for each illustration, a *starter* page (e.g., [5]) which typically puts together contextual information drawn from various sources (e.g., fragments from multiple slides, tailored drawings). Given that the resulting starting pages are digital, they are *maintainable*: they may be refined after repeated delivery sessions and/or mere mental simulations. Equally valuably, they are *reusable*: (parts of) starter pages designed for one session may just be adapted (via simple copying and pasting) for another session meant for a similar subject.
- Delivery is, to a great extent, unpredictable, as the *dynamic* of each session may differ, and the factor of nervousness may always be present. My best advice would be that the more prepared one is in producing the starter pages (and thinking through how they are to be presented and annotated), the more confident one will feel in the live deliveries.
- Both Setup and Sharing boil down to routine tasks that can be (virtually) perfected through repetitions. For example, to set up the various equipment items (Section 5) for an in-class, live lecture, it now takes me just a few minutes.

Numerical results from the post-course, anonymous surveys revealed that all cross-disciplinary participants expressed a *unanimous* consent that the course learning outcomes have been achieved, and that they may adapt/adopt my approach. Moreover, here is a written comment that is representative of what most participants expressed to me informally:

"I am leaving the course with confidence in developing and delivering lectures using both my iMac and iPad. Synchronous webinars (Q & A sessions) usually involve the practice of skills learned, and being able to demonstrate diagraming and evaluating skills beyond the use of the whiteboard (which is limiting), will improve teaching students argumentation skills. Organizationally, Jackie is pushing us to develop starter pages - and these templates can be used repeatedly. I'm glad that he kept repeating this point - because when I'm in survival mode I am just building course material each day of class. I think I can prepare and manage this better (with little extra effort) with a templates book in Goodnotes and then using a "copy" of the starter page. ..."

9 FUTURE WORK

Because my online assessments are drastically different from those conducted prior to the pandemic (e.g., types of questions, lack of invigilation), I have not yet collected sufficient student performance data to report. As future work, I will conduct such comparison when more online instances are run. Also, I will continue to run the service course (Section 8) regularly, for both Windows and MacOS instructors, and report observations and insights.

REFERENCES

[1] S. A. Ambrose, M. W. Bridges, M. DiPietro, and M.C. Lovett. 2010. *How learning works: Seven research-based principles for smart teaching.* Jossey Bass, San Francisco, CA.

[2] Blue. [n.d.]. Blue Yeti: Professional Multi-Pattern USB Mic for Recording and Streaming. https://www.bluedesigns.com/products/yeti/.

[3] H. Ebbinghaus. 1913. *Memory: A Contribution to Experimental Psychology.* Teachers College, Columbia University.

[4] FIFINE. 2018. USB Wireless Microphone System for PC and Mac. Model K031B.

[5] C.-W. Wang. 2017. Gallery of Starter & Annotate Pages (lectures, tutorials, Q&A). Online. https://www.eecs.yorku.ca/~jackie/teaching/iPad.

[6] C.-W. Wang. 2017. Lectures Site (recordings, iPad visual notes, etc.). Online. https://www.eecs.yorku.ca/~jackie/teaching/lectures.

[7] C.-W. Wang. 2017. Teaching Channel. YouTube. https://www.youtube.com/user/jackiechenweiwang.

[8] C.-W. Wang. 2017. Tutorials Site (recordings, iPad visual notes, exercise sheets, etc.). Online. https://www.eecs.yorku.ca/~jackie/teaching/tutorials.

[9] C.-W. Wang. 2019. Creating Tutorial Materials as Lecture Supplements by Integrating Drawing Tablet and Video Capturing/Sharing. In *8th Computer Science Education Research Conference (CSERC).* ACM, 1–8. https://doi.org/10.1145/3375258.3375259.

[10] C.-W. Wang. 2019. Integrating Drawing Tablet and Video Capturing/Sharing to Facilitate Student Learning. In *1st Global Computing Education Conference (CompEd)* (Chengdu, Sichuan, China). ACM, 150–156. http://doi.acm.org/10.1145/3300115.3309530.

[11] C.-W. Wang. 2021. Course Syllabus: Using a Drawing Tablet to Craft Educational Videos for Visual Learners. Online. https://www.eecs.yorku.ca/~jackie/teaching/tc/syllabi/syllabus-creating-educational-videos.pdf.

[12] B. Oakley, B.R. EdD, and T.J. Sejnowski. 2021. *Uncommon Sense Teaching: Practical Insights in Brain Science to Help Students Learn.* Penguin Publishing Group.

[13] Masschusetts Institute of Technology. [n.d.]. MIT Open Courseware. https://ocw.mit.edu/index.htm.

[14] Active Presenter. Version 9. All-in-one Screen Recorder, Video Editor & eLearning Authoring Software. https://atomisystems.com/activepresenter/.

[15] Korea (SUNY Korea) State University of New York. Established in March 2012. https://www.sunykorea.ac.kr/en/.

[16] Time Base Technology Ltd. [n.d.]. GoodNotes 5. https://www.goodnotes.com/.

[17] Stanford University. [n.d.]. Stanford Online. https://online.stanford.edu/courses.

[18] G.P. Wiggins and J. McTighe. 2005. *Understanding by Design.* Association for Supervision and Curriculum Development.

[19] J. M. Wing. 2006. Computational thinking. *Commun. ACM* 49, 3 (2006), 33–35. https://doi.org/10.1145/1118178.1118215 http://doi.acm.org/10.1145/1118178.1118215.

[20] Revolabs xTag. 2007. Wireless Microphone System. Model 02-DSKMAN-DPP-11.