Drawn together: Integrating words with visuals while annotating textbooks and articles for strengthening competencies in computer networking technology

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Abstract

Computer electronics and networking technology textbooks and technical documentation abound with jargon, specialized symbols, complicated procedures, mathematical maneuvers, along with numerically dense charts and tables. These can make the text difficult for a student to navigate effectively, often making it a task reserved during the exams if that. Annotating documents can be instrumental in providing students with both a broader and more in-depth grasp of the content. It has the potential to make it both actionable and enjoyable, even when it is challenging to do so. Additionally, annotating technical diagrams in the text, whether these be network topologies, wiring diagrams, circuits, flowcharts, can provide the reader with a multi-faceted view beyond the one that was initially present, including a personal perspective. It allows the student to participate actively in the content creation process alongside the author.

Annotating textbooks and articles related to computer networking topics requires careful reading of the content. Doing so allows students with the time needed to build and strengthen learning connections with new and complex topics as they consider the information in multiple ways. At the same time, it increases their flexibility about the annotation process, as they have full control over the process. By repeatedly practicing this, it builds endurance and muscle memory about the annotation process itself. The act of close observation, requiring noting both what is being said and possibly being left unsaid by the author, sharpens one's thinking. It also makes memorization of, and associations between topics more readily possible.

The technical note-making process is also resulting in the transfer of learning across the curriculum. Students in computer networking classes have commented on how this deliberate annotation process is making them read textbooks and articles in other courses more purposefully, often with pencil, colored highlighters, or stylus in hand. The presentation includes information about free and open-source software that allows annotations of electronic documents.

Keywords

Critical reading, Annotation, Network diagrams, Icons, Symbols, Encode, Decode information, Visual thinking

Introduction

Reading of any sort in general, and technical reading, in particular, naturally raises questions about the topics. It invites engagement and application of theory to practice. When students feel intrinsically compelled to add their notes next to examples or procedures in the text, they are going beyond merely reading it. Self-Determination Theory (SDT) [1] provides a framework for understanding how to promote motivation. By supporting the three basic psychological needs of competence, autonomy with individuals acting in their self-interest, and relatedness with others, individuals are motivated and energized by self-determination. The visceral element to intrinsic motivation we feel about performing a task contrasts with extrinsic motivation, which interferes with one's sense of autonomy. One of the challenges regarding the reading of an informationally dense technical text is the motivation to do so. Additionally, researchers in [2] found that even

though students might realize that reading the assigned text is vital for being successful in the course, they have difficulty prioritizing the many learning tools available, including supplemental materials. The single most significant constraint they found was the time available to students.

[3] identifies cognitive load being a crucial component that affects the amount of meaningful learning that can occur. It posits that the information we comprehend is the organization of coherent verbal and pictorial representations. They state that for such learning to occur, learners have to engage in a significant amount of cognitive processing in their verbal and visual channels. However, the capacity of these channels is quite limited. They suggest various methods for reducing the load on these. By integrating both these ways of encoding information with one's prior knowledge, results in meaningful learning, wherein one can apply it to new situations. Their experimental work builds on the dual-coding theory hypothesis [4], which postulates that distinct channels process visual and verbal information. These create separate representations using visuals, imagery, and verbal associations, respectively. [5] explores the use of visuals with words to explain technical concepts. Judicious use of graphical elements such as lines, shapes, forms, colors, contrast, alignment, proximity, repetition, and space, can aid learning. This ability to encode a given stimulus in different ways, both visual and verbal, improves the likelihood to retrieve and decode it at a later time.

As we read a topic, we link together our previous knowledge, pieces of information, experiences, and emotions. We activate our existing base of knowledge, skills, and attitudes, to think about a topic or think through a given scenario. Various memorization techniques can increase this repository of prior knowledge, which can then be linked with the new content as we read. [6] reviews mnemonic devices to remember information. Most of the strategies involved the use of imagery and verbal strategies for forming mental linkages, images, and sounds. They caution, though useful as a way to enhance learning and recall of information, mnemonics are not comprehension strategies, with a weak linkage between the conceptual content and the material. These need to be borne in mind while creating mnemonics. Not surprisingly, the mnemonics developed by a student are the most likely to recall. We can use the finding that self-developed verbal or visual mnemonics strengthen memorization to motivate learning of core knowledge and skills in the discipline.

Rich Pictures (RP) is a diagrammatic way of identifying different views to create a common or shared understanding and is mainly a freeform drawing tool. [7], in the context of RP, recommend associating key legends with the pictures as this can make deciphering the true meaning of the icons. In [8], cartoons serve to develop connections between the concepts covered in a course on Dynamics and Fluid Mechanics. These can help the student grasp and also retain the concepts. The instructor for the class created the cartoons, and this led to improved engagement in the topics. The whimsical aspect of the cartoons helped students relate to the content. In the TED Talk [9], crafting a narrative out of data, or for that matter, out of any piece of information one is presented with, makes visualization a compelling way of expressing its meaning. When we keep the content at the center and use visuals effectively to encode the insight, it has the side-effect of making the memory traces stronger. New meanings now link up with the word or image. It enlarges our repository of learning connections. Using self-drawn

visuals, along with verbal annotations, allows the creator to play with ideas. It makes the memorization and adaptive use of these ideas in different contexts easier.

Annotating class-notes by interspersing visuals with words can be extended to annotating textbooks or other online materials. In [10], the web-based annotation platform, Perusall, was used in a course on Fluid Mechanics for annotating an online text and journals papers, with both prompts by the faculty member seeding the annotation process, along with requirements for students to post and respond to questions or annotations made by others. The machine-learning algorithms that are built into Perusall automatically grade student comments. The instructor can verify that the grade is consistent with their assessment.

Referring to their annotated class notes, text, and optional online references, students can apply their knowledge to design networks and step through the process of configuring network devices in laboratory activities. As part of the reviews for exams, students can also annotate their class notes, and their annotated textbook as well. In doing so, they are, in a way, talking to their earlier selves about their prior understanding of the topic. Along with considering various perspectives, students are also learning to consider possible positive, negative, and exciting implications of the reading. These are all powerful ways of connecting readers with content.

Network Switches & Routers Course Information and Instructional Methodology

The Network Switches & Routers course, NET 343, is offered through the Cyber Systems Technology (CST) program in the Department of Applied Engineering & Technology (AE&T) housed within the College of Business & Technology (CBT) at Eastern Kentucky University. It primarily covers internetworking, switching, network operating systems, Virtual Local Area Networks (VLANs), Access Control Lists (ACLs). The instructional methodology uses a combination of lectures, demonstrations, and laboratory activities. Both simulation software and hands-on activities with physical network devices provide students the opportunities to configure, secure, test and troubleshoot, and manage, monitor, and improve network hardware.

The pre-requisite for the course is LANs & PC Communications, where students learn the foundations of computer and network communications systems hardware and software. Students have the opportunity to build network cables, set up wired and wireless networks, install various types of servers such as Web, File, Proxy, Email, primarily running on Windows Operating Systems. They also explore running various Linux Operating Systems in virtual environments.

The textbook for the Network Switches & Routers course is the *CCENT Cisco Certified Entry Networking Technician study guide ICND1 exam 100-101* (3rd ed.) by Todd Lammle. The reference text for the course is CCNA 200-301 Official Cert Guide, Volume 1, Wendell Odom. The initial chapters of the textbook deal with core networking theory topics such as network reference models, Ethernet, TCP/IP, Subnetting, Variable Length Subnet Masking (VLSM), and include end-of-chapter Written Labs and Review Questions. After introducing the Cisco Internetworking Operating Systems (IOS) software, the course and the associated chapter in the text cover device and network management, routing, switching, VLANs, security using ACLs, Network Address Translation (NAT) and the latest version of IP addresses, IPv6. Configuring the complete network system requires exclusive use of the text-based, Command Line Interface (CLI). Getting familiar with the CLI has traditionally been a challenge for students, as there are

numerous commands with their specific syntax. It takes a considerable amount of practice to acquire proficiency using the CLI. To ease this transition, later chapters in the text include network simulations. In-class activities guide student work, direct them to suitable readings in the text, and for completing the associated laboratory writeups.

Assessments include a mid-term and a final exam. Each assessment includes an objective-type section with questions similar in structure to the related network certification exam. A short-answer scenario type section requires students to design and theoretically set up computer networks. The final exam also includes a comprehensive hands-on group final, which requires the design, cabling, configuration, securing, testing, and troubleshooting (as needed) of a managed network using LAN and WAN links, along with network server applications and clients. This hands-on final serves as the core guiding activity throughout the semester, with students being introduced to various pieces of the computer networking puzzle as they progress through the semester.

Course activities include detailed hands-on laboratory activities that student groups complete, requiring configuration of physical network hardware switches and routers for ensuring end-to-end connectivity across a network. Various updates in the Cisco Certified Network Associate (CCNA) exam come into effect in early 2020. Even following the update in the core part continues to include almost all of these topics. Students should be able to understand the need for the Spanning Tree Protocol (STP) used to allow redundant paths in a switched network traffic without causing loops. They need to use industry-standard network routing protocol, Open Shortest Path First (OSPF), as a replacement for Routing Information Protocol (RIP). They also need to have a deeper understanding of security and IP services. Follow-up network hardware courses in the curriculum intended to cover more advanced topics such as network automation, controller-based networking architectures, including the cloud, specialized security, IP services, and wireless networking systems.

Annotations in the Network Devices Course

Visual annotations in technical texts may serve as quickly scannable anchors of sorts, allowing us to identify and re-read portions of the book while working on specific applications or activities. For example, directing students to review sections of the text for safety-related icons or symbols they may have created, can cue their learning of the topic more effectively. They can then apply these concepts more effectively while working with computer electronics systems in a lab. Also, it harnesses the power of visual representations, a dimension with which we as humans perform very well. They create their codex of visual and verbal symbols for identifying specific constructs in the text, leading to greater autonomy over the actions that lead to personal ways of understanding the content.

Using examples, students are familiar with and find it easy to draw, can be very helpful in the visual annotation process. Food-inspired illustrations are used frequently in the class, and these are very close to one’s personal experiences, allowing one to mentally sense (see its presentation, smell the aroma, hear the sizzle, taste the crunch, and even reach out to touch the food). In the networking devices course, associations using the other senses are encouraged, especially that of taste, smell, and texture, bringing one closer to the experience. Examples relating to popular foods and experiences such as gaming evoke stronger associations with the technical content.

Figure 1 shows how a pizza introduces class discussions on the analysis process, and the items to focus on while reading or annotating the text.

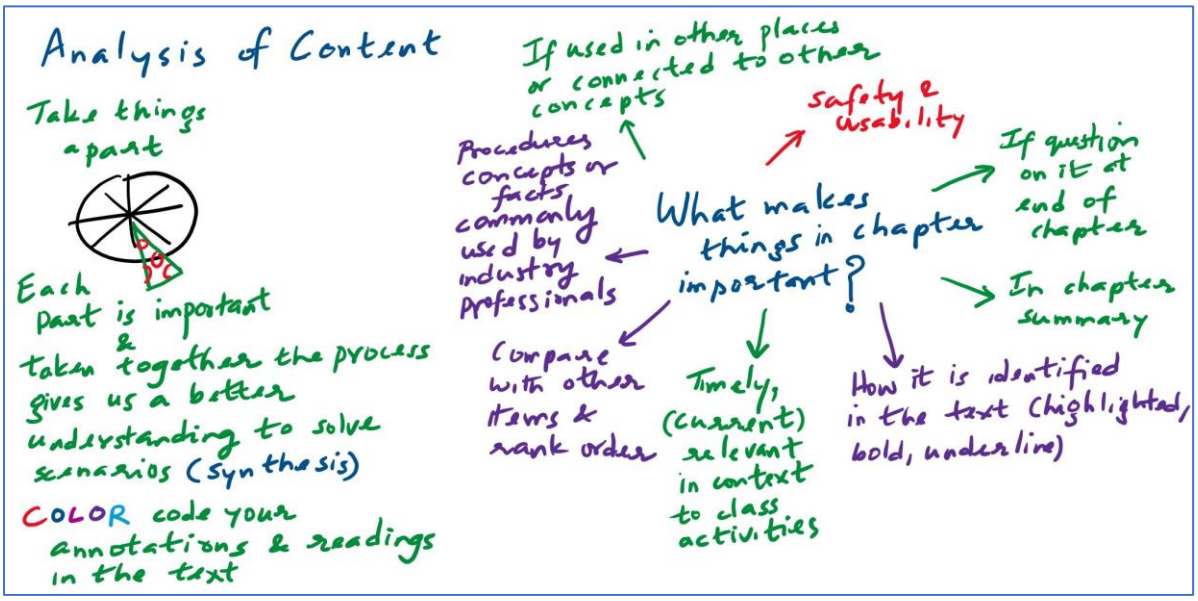


Figure 1. Comparing the process of analyzing a networking system to a pizza.

Fun, often visual, ways of memorizing baffling acronyms, standards, procedures, shared in the classroom, can elicit laughter, and make the content more memorable for then students. These personalized ways of learning content thus have the potential of "sticking" longer and thus of being applied more readily in various contexts. For example, while introducing various IEEE 802.3 Ethernet standards ranging from 10 Mbps to 10 Gbps, to make these more memorable, we need some mental visualization and jugglery of the networking terms. The vanilla version of the standard, operating at 10 Mbps half-duplex mode using Twisted-pair cabling, or 10BaseT, is IEEE 802.3 (the standards project named after the first meeting of the working group in 1980 February). The 100BaseTx refers to the IEEE 802.3u standard, and we can visualize it as a user in a "Tux" unruffled by the ten times higher speed over the standard 10 Mbps. The 1000BaseT refers to the IEEE 802.3ab, and we can visualize as a power user with a thousand open web browser "tabs." The 10GBaseT refers to IEEE 802.3an, which we can visualize as a vacationing network engineer on the beach is getting a "tan" while accessing this superfast network connection. Associating the cabling with the standard has been adopted in class with some sighs and laughter by the students. Figure 2 shows a digitized version of the board notes associating various IEEE standards with the specific Ethernet cabling speeds.

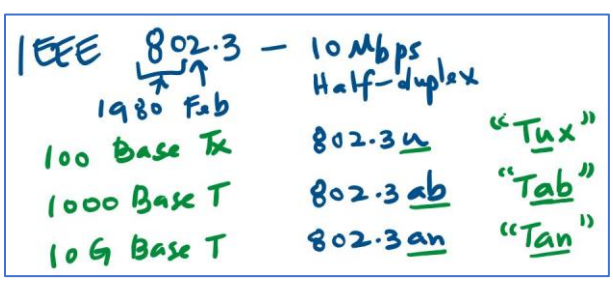


Figure 2. Visuals for linking the IEEE 802.3 Ethernet standards with network speeds.

Memorizing port numbers associated with the TCP/IP Application layer protocols can be made a bit easier for the ports that lend themselves to easy visualization. For example, the Network Time Protocol (NTP) uses Application port number 123. We may view this to be a clock showing 3 o'clock. Piggybacking off the NTP analogy, the telnet protocol offers a network administrator a quick way to set up a text-based console connection between a computer and a network device uses port 23. It can be shown visually as an individual (I) being able to establish a quick and convenient connection with a network hardware device. The Network News Transfer Protocol (NNTP) uses port 119. It would seem like a problematic port number to memorize; however, if one imagines looking at this number reflected in the mirror, it would be "911" -- which for reasons yet unclear to the author -- is what most news these days is. An open newspaper shows the 119 port number with images and text regarding the news of the day. Email is an extensive globe-spanning system which can be shown by a whale, with the Simple Mail Transfer Protocol (SMTP) used to send emails (whale's blowhole), POP for incoming mail (whale's belly). The Internet Message Access Protocol (IMAP) is a two-way incoming mail (shown near the forked tail). While the drawing may not be anatomically correct, it can still convey a lot of the features of the email system. Figure 3 shows the possible links between various Application Layer port numbers and suitable visuals cues.

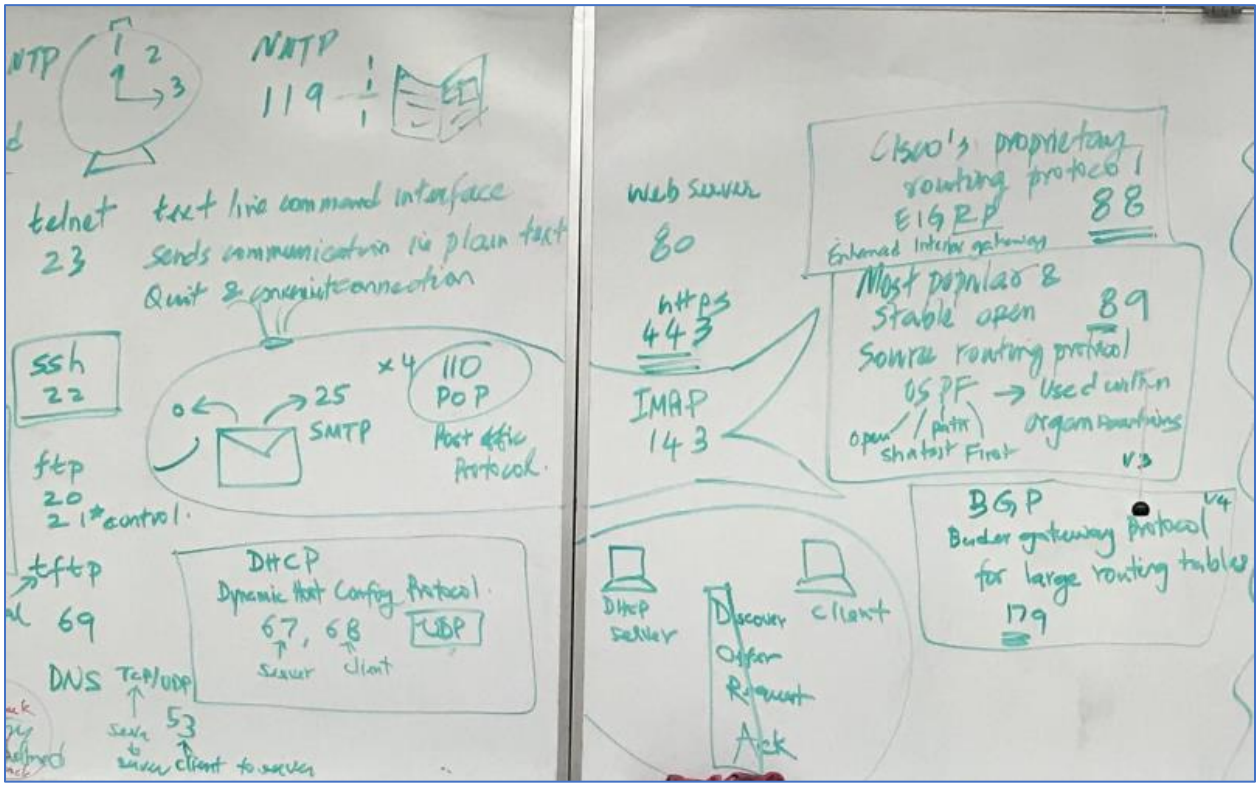


Figure 3. Visuals for linking TCP/IP Application layer protocols with port numbers.

The pizza analogy also works for showing students the need for and limitations of classful IPv4 networks. For example, a non-sub-networked Class C, IPv4 network, has 8 bits assigned to the host portion, which means it can support up to 2^8=256 hosts, which is a hard limit. If we now choose to divide this network into two halves, each sub-network can, at most, support 256/2=128

hosts each. We can show this very conveniently by slicing the pizza in half. The process can continue successively by using up more host bits for creating subnetworks. Design questions related to this topic require students to design a specific number of subnetworks, each containing a specific number of hosts. Based on the understanding of subnetting gained by slicing the network pizza, students learn about creating a compact subnetting table for Class C, IPv4 networks, and later extend this to other network classes. While proficiency in this takes a lot of in-class and homework practice, students have come actually to enjoy the process.

When the network slices are not all the same size, representing some subnetworks requiring additional hosts, we experiment with alternative ways of slicing the pizza. We illustrate the rules of Variable Length Subnet Masking by a pizza in which the slices are cut based on how much of it one may want to eat. As the Network Switches & Routers class often meet close to the lunch hour, all the talk of pizza and other juicy foods has students commenting on how hungry it makes them.

Metaphorical thinking and mental imagery are useful in making new learning connections [4]. Drawing comparisons between dissimilar systems allows us to embed useful information in unexpected ways. When students use their own words and personal visuals to encode new vocabulary terms that they have been reading about, their understanding is enhanced. The annotations could include standards, theories, definitions, principles, laws, or the applications of these technologies. For example, Figure 4 includes the picture of a student's notes indicating the need for closer inspection of the EtherType field for identifying IPv4 and IPv6 traffic within an Ethernet frame. Once keywords link with visuals [5], it facilitates flexible retrieval at a later time.

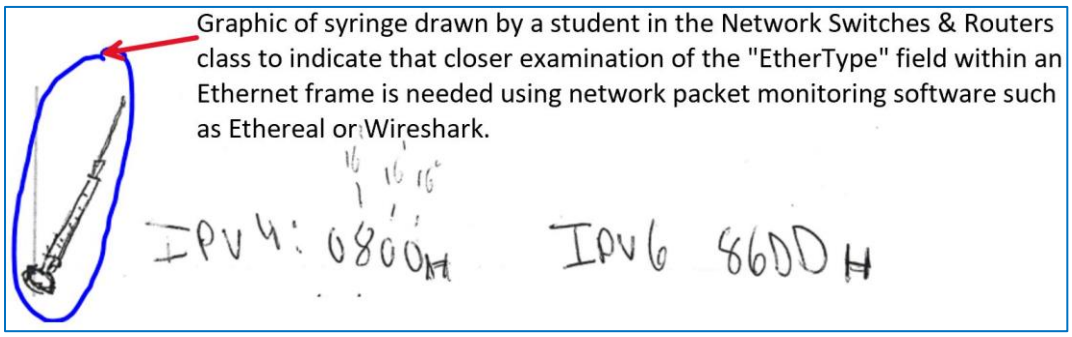


Figure 4. Sample of student class notes with personalized visuals for examining network traffic

In the Network Switches & Routers class students design and configure IP networks. For this they need to access and configure network devices using the text-based Command Line Interface (CLI). Typically, network hardware devices, offer multiple modes of access to their Internetwork Operating System (IOS), each corresponding to specific privileges. We can visualize this as a "tree" type structure, with the manner of access to the device -- either via the console, Aux, or VTY (telnet) -- serving as its roots. Specific commands allow one to ascend and descend the tree trunk. Figure 5 shows this way of navigating the different IOS modes. In some ways, this is reminiscent of board games as well, an analogy that can convey this concept to students.

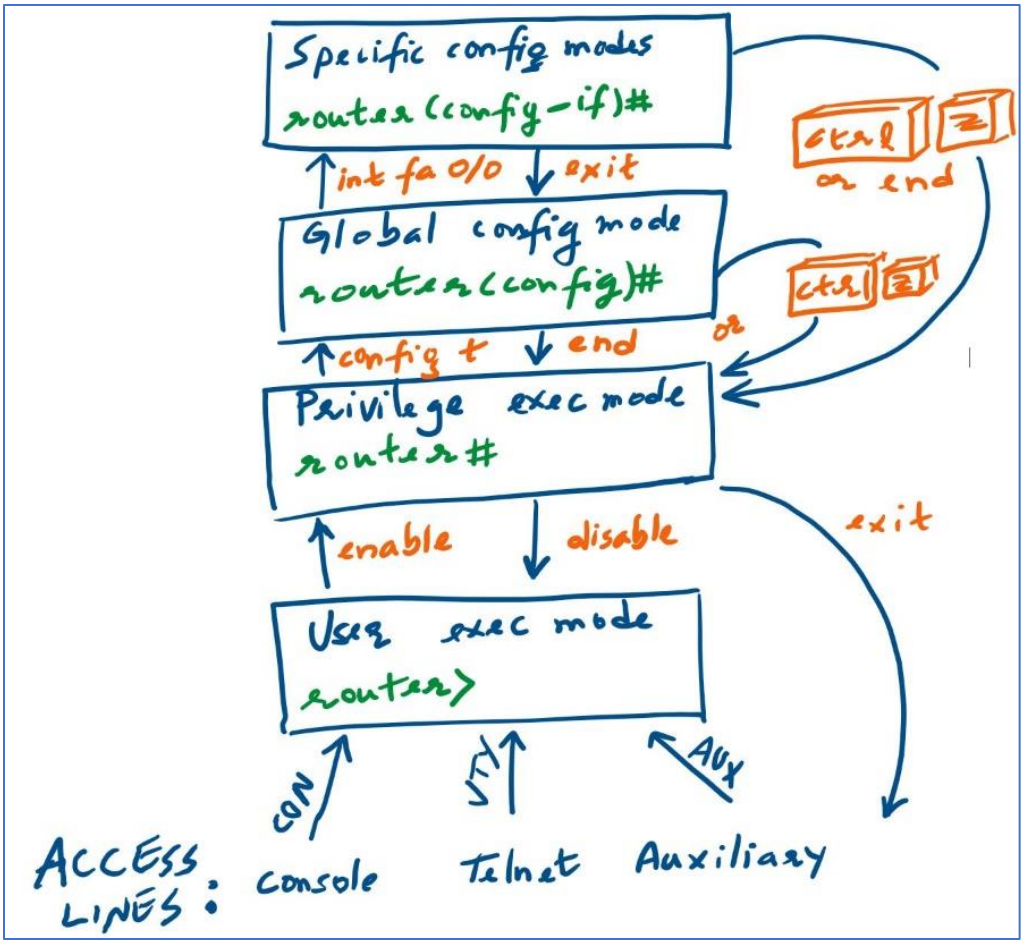


Figure 5. A visual depiction of various IOS modes. Repeated practice, mental visualization, sketching out how one may navigate using only text-based commands builds muscle memory.

In [11], text structures guide reading about one's understanding, supporting the comprehension of the content. For informational texts, these include structures such as descriptions, sequences, compare and contrast, cause and effect, and problem and solution. These structures link readily to the graphics and illustrations included in an informational text. Building a strategic awareness of the type of graphics can help guide a deeper understanding of the text. For example, network diagrams are a type of narrative structure, flow charts are a type of sequences, and practical network troubleshooting examples, a sort of cause and effect structure. The authors emphasize that students "must create their graphics to accompany the informational texts they are writing."

The use of personal icons and symbols can provide consistency to the annotation process while reading textbooks or reviewing class-notes. We share these during class discussions. It helps build a common -- and at the same time, individualized -- visual vocabulary. Figure 6 shows familiar icons and symbols in the Network Switches & Routers class. It includes borrowing vocabulary out of the millennials' playbook by using texting or online gaming abbreviations [12] and creating simplified drawings which Merkley [13] refers to as the Zen of Icons.

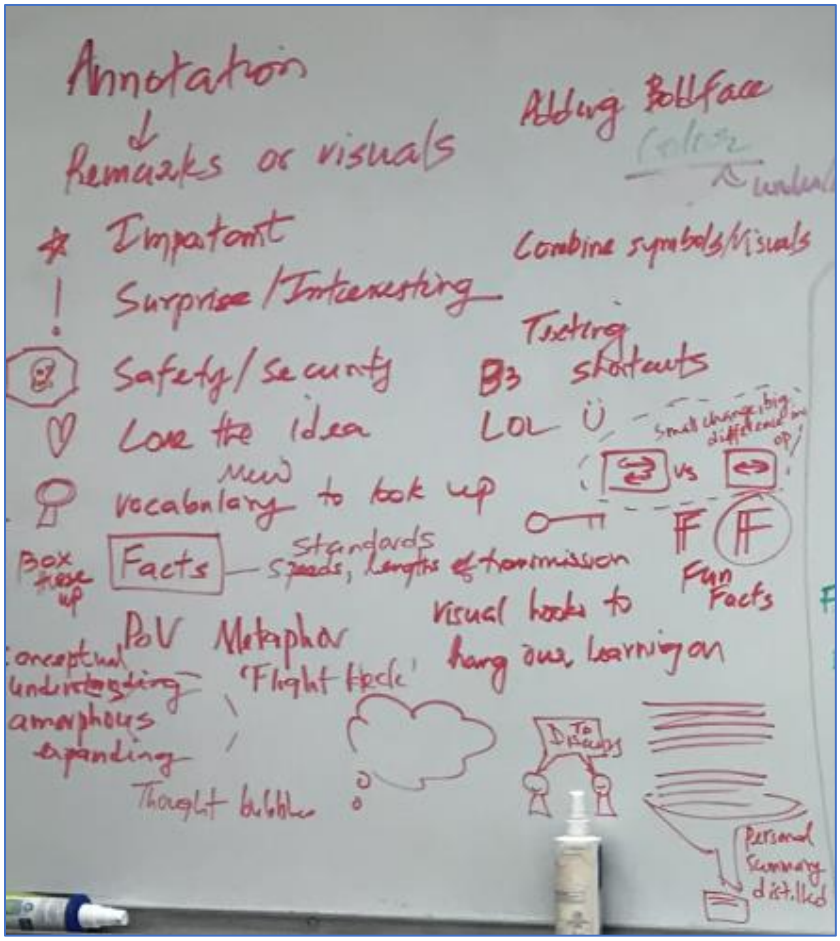


Figure 6. Standardizing icons and symbols for annotating textbooks.

Additionally, as part of the lab reports for each chapter in the text, students identify key networking terms, separating these into Key Facts and Concepts (KFC), a potentially appetizing fast food analogy for many college students. To this, we later add "sequences," referring to step-by-step procedures and calculations perform. In Figure 7, we explore the link between facts and concepts.

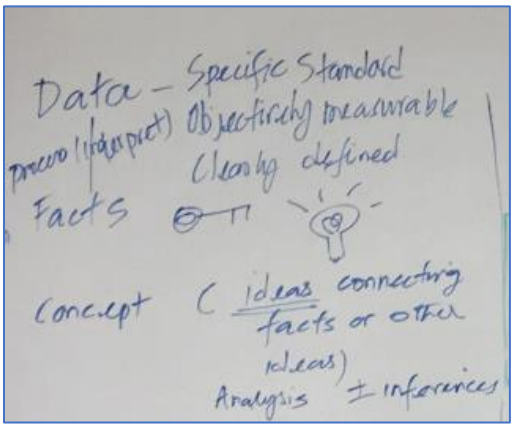


Figure 7. Students use the abbreviation KFCs which refers to the Key Facts and Concepts derived from the assigned readings in the text.

Any kind of drawing supports and strengthens an alternative representation of information. Students are encouraged to annotate their drawings for clarity, mainly when non-standard or personalized symbols are in use. They can also enlarge their repertoire -- something the instructor is working on -- by tracking down and practicing drawing icons for various objects. The Noun Project [14] is a treasure trove of freely available drawings of objects created by artists from around the world. Anyone can contribute to the project. Figure 8 shows the main page of the Noun Project. With "icons for everything, and a goal for "creating, sharing and celebrating the World's Visual Language," it offers inspiration for improving one's drawing skills.

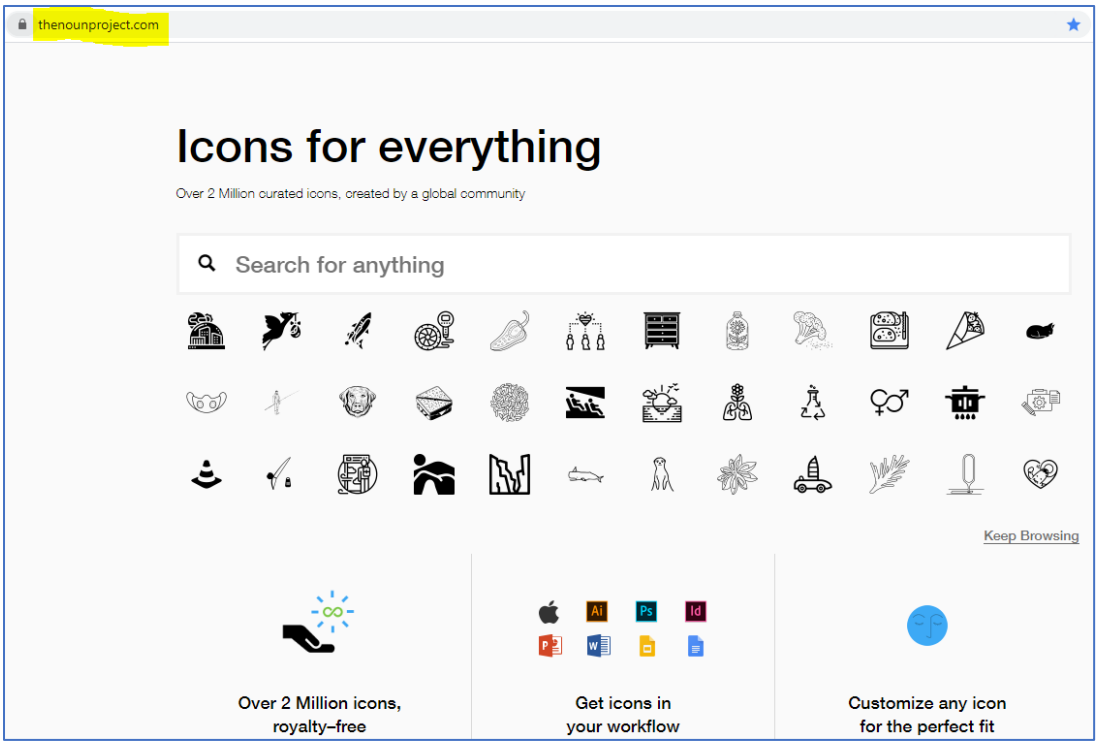


Figure 8. The Noun Project website includes access to royalty-free sketches of objects. More importantly, these sketches are suitable as practice prompts for visual annotations.

Additionally, free open-access graphics sketches, symbols, and icons of objects are available on the Internet for viewing or download as practice prompts. Websites, such as Pixabay (https://pixabay.com/), Unsplash (https://unsplash.com/), and Flaticon (https://www.flaticon.com/), contain free, high-quality illustrations. These include numerous vector graphic illustrations, which are scalable, transparent background images. For students, or faculty, who enjoy putting pencil (or pen) to paper (or tablet) for doodling or sketching, these websites offer plenty of visually stimulating information. Tags link individual illustrations with the objects, making the content easily searchable. Figure 9 shows some of the typical computer and business-related icons.

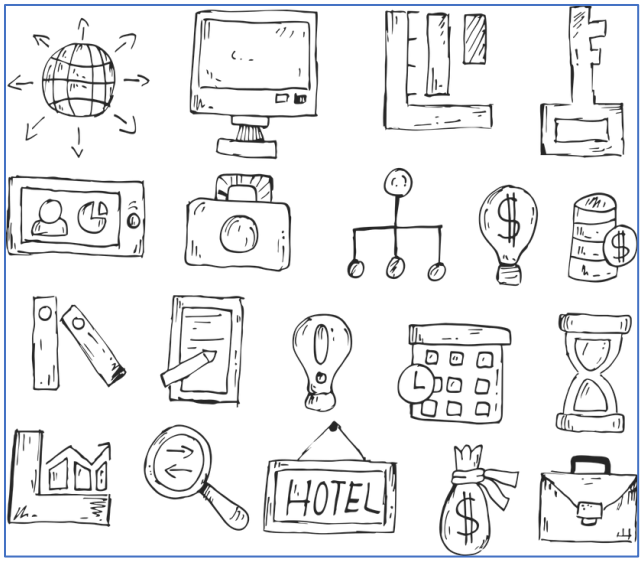
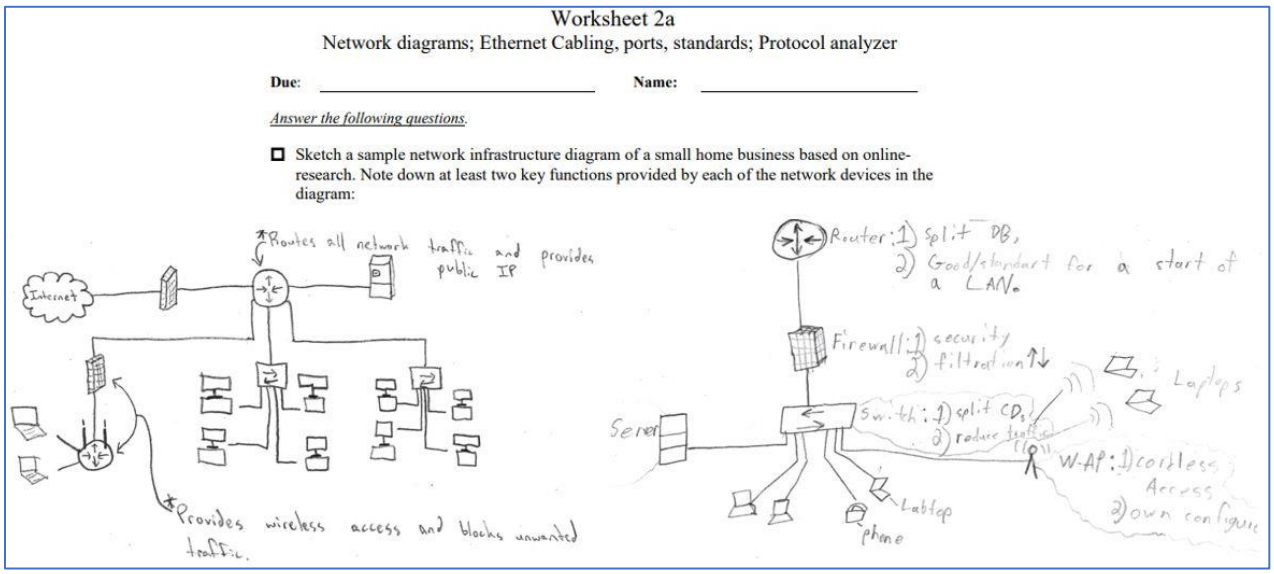


Figure 9. Free vector graphics are available through Pixabay and other websites. This set is by jozefm84 from https://pixabay.com/vectors/icon-finance-bank-electronic-4102192/).

When we share with students the pleasure of seeing our hand-drawn icons adorning the sides of textbooks or notes-for-class, they may be curious enough to explore it as well. Over time and with the opportunity to practice, this can build confidence in creating one's personalized visual vocabulary. A select set of icons can add personalized meaning to textbooks, technical resources, and other readings.

With the extensive use of the whiteboard used in the class for communicating technical information, along with numerous in-class activities, students have opportunities to practice creating suitable technical visuals and annotating these with meaningful text. This type of dual coding of information [3, 4] then allows them to practice this skill more readily outside of class while conducting their reading of the textbook or technical resources. It encourages the development of personal visual vocabulary. Figure 10 shows a sample in-class activity requiring a sketch of a sample network diagrams for a Small Office Home Office (SOHO) based on their in-class online research.

In the Network Switches & Routers class, I share my attempts at annotating the course text combining both words and visuals. To somebody else, the connections between my diagrams and different parts of the page may seem like a bowl of spaghetti. It is also a bowl of personal technical meaning established through the linkages on the page. When students see that my images are just personal representations, they learn, both in subtle and direct ways, that this is mostly an individual endeavor. They are free to put pen to paper. Or to the smart screen as the case may be. Doing so creates meaning. Personalized visuals, the icons that students use while annotating, can be shared out in the class. It allows students to learn from each other's learning experiences. Owing to the highly personalized nature of creating visuals for objects [7], the sharing of visuals also introduces some ambiguity in the mix. We remind ourselves that the ultimate meaning of the visual is literally in the eyes of the beholder. What matters is the unique learning connections their visual evokes.



Worksheet 2a

Network diagrams; Ethernet Cabling, ports, standards; Protocol analyzer

Due: _____ **Name:** _____

Answer the following questions.

☐ Sketch a sample network infrastructure diagram of a small home business based on online-research. Note down at least two key functions provided by each of the network devices in the diagram:

Figure 10. Worksheet requiring students to sketch networks using standard symbols following in-class online research using their mobile devices.

The annotation process for texts is being extended into the Internet this academic year for the Network Switches & Routers class. [15] uses the open annotation tool Hypothes.is in a class reading Victorian texts. The tool allows highlighting or annotating any element of a web page in a public (default) or private group setting. The private group setting limits user access to the annotations and is convenient to use in a classroom setting. The instructor may direct students to respond to a minimum number of prompts after seeding the document with starter prompts. They may also need to create a minimum number of annotations responding to the highlighting or annotations by others. Hot spots in the text appear quickly as more students annotate or highlight specific sections. It is easy to deploy Hypothes.is as a bookmarklet or conveniently as a browser plugin. The ability to anchor commentary to specific portions of the text leads to increases in interactions. It allows for intuitive online interaction with both the text and other participants if one so chooses.

In the Network Switches & Routers course Hypothesis.is students are exploring this handy online resource for reading technical information online for individual use. Screen clips of the annotations students generate may be included as part of the course portfolio in their references. In contrast to [10], which is available for use only with designated textbooks and uploaded PDFs, [15] is a much more accessible, open-source annotation resource. It is easy to add annotations to web pages and PDF documents. As students begin using this tool, they think of it as a power-packed web browser bookmark that allows personal commentary. So, the next time a student revisits a webpage they found useful, a helpful annotation or highlight is waiting for them. It allows for quick scanning of the web page and refreshing one's memory. Figure 11 shows the use of an open annotation tool for adding annotations.

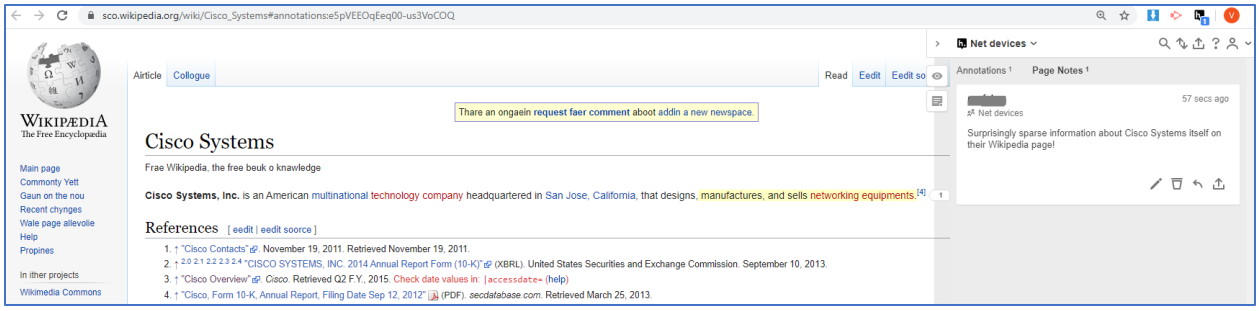


Figure 11. Hypothes.is used to annotate the Cisco Systems Wikipedia page, adding highlighting and commentary. Additionally, images, such as copyright free ones from Pixabay, can be readily added to the annotations.

Student Assessment

Strategies for actively engaging with the textbook consistently across a course, from one chapter of the text to the next, build confidence regarding one's competencies. It includes developing visual and verbal annotations for both in-class and text resources, summarizing Key Facts and Concepts (KFCs), and documenting their ongoing work through a portfolio. It can be exhilarating for the student to look back and wonder about the amount of content they have navigated through over the semester. It also allows them the confidence to jump back in quickly where they left off after a quick review.

Students have multiple opportunities to reflect on the learning competencies associated with the course. Summary student comments on the visual with verbal note-taking methods used in the Network Switches & Routers class include:

> *"1st concept – accurately visualizing how each network device connects to one another and the role played by each device. The puzzle of the network makes sense."*
>
> *"It has taught me to take good concise notes which are especially important for this class …"*
>
> *"This really helped me bridge the conceptual information I've gained from my prior classes to actual, practical knowledge and skill."*
>
> *"What information I thought I knew well was enriched, and the amount of new information exceeded my expectations. Being able to put the new information into practice and being able to run into stumbling blocks greatly solidified what I was able to take away from the lectures."*

The final exam for the course includes a hands-on group portion, requiring them to design and deploy a managed network. Students first establish an end-to-end connection between a server system of their choice at one end and a suitable client for the specified server at the other. Their connection goes through at least two or three managed routers and two managed switches, for which they set up the wiring. Student groups have installed games such as Terraria on Steam, which also has Terraria TeamSpeak server, allowing for VoIP communication over the network. Students first confirm network connectivity and then using an Access Control List (ACL) block game access, while still permitting ping traffic, which uses the Internet Message Control

Protocol (ICMP). Figure 12 shows an illustration of the hands-on final group activity. Students enjoy the opportunity for putting the theory of networking they have learned into practice, accessing their course portfolios. Students bring completed and annotated worksheets, labs, notes, references, and text for use on the final hands-on exam.

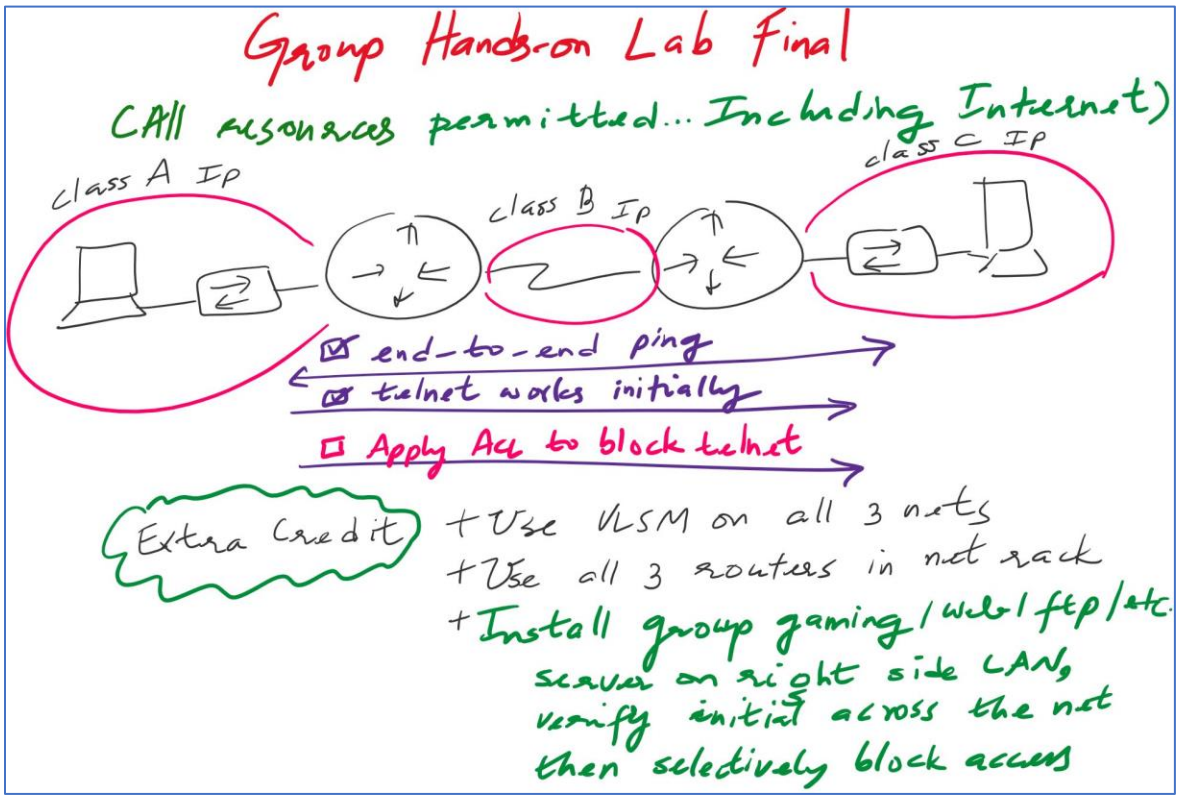
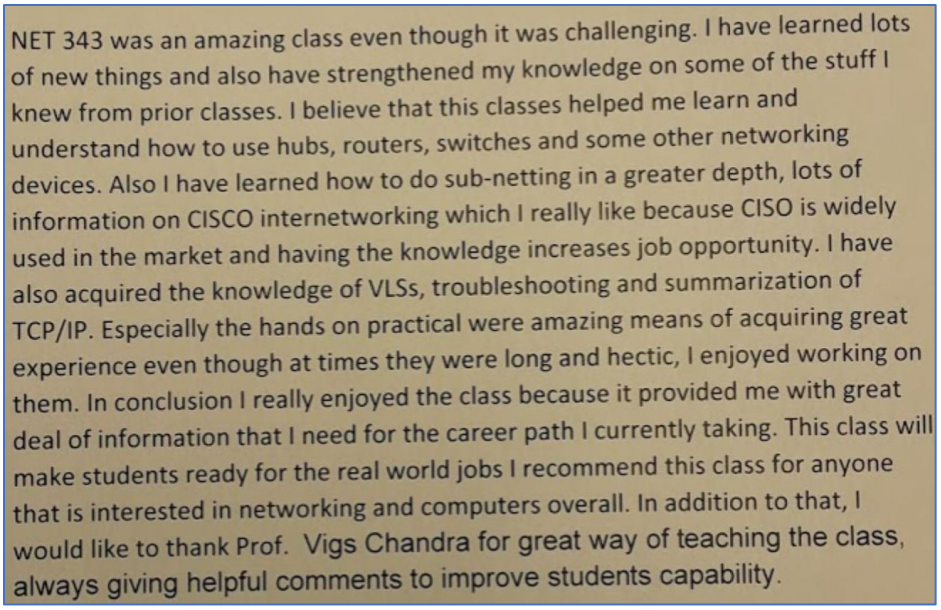


Figure 12: Hands-on laboratory activity requiring the installation of a server (such as Terraria, a gaming server; telnet; VoIP; VPN) and a corresponding client on separate computer systems connected by managed network devices.

All students are required to maintain a portfolio documenting their work. It includes the in-class worksheets, online work with faculty feedback received, simulation and device laboratory activities, assessment corrections, references, and a course learning statement.

In the course learning statement, students comment on their achievement of the competencies. They include updates in their knowledge, skills, and work practices for the course over the semester. This practice allows the student to travel back in time to the start of the semester and take a closer look at the new things they know, can do, and how they are developing as network professionals. Students are also being encouraged to depict these three dimensions visually, adding annotations to their visuals for elaborating on their perceived level of competencies in these three areas. Figure 13 includes comments by a student reflecting on the core competencies of the course.



NET 343 was an amazing class even though it was challenging. I have learned lots of new things and also have strengthened my knowledge on some of the stuff I knew from prior classes. I believe that this classes helped me learn and understand how to use hubs, routers, switches and some other networking devices. Also I have learned how to do sub-netting in a greater depth, lots of information on CISCO internetworking which I really like because CISO is widely used in the market and having the knowledge increases job opportunity. I have also acquired the knowledge of VLSs, troubleshooting and summarization of TCP/IP. Especially the hands on practical were amazing means of acquiring great experience even though at times they were long and hectic, I enjoyed working on them. In conclusion I really enjoyed the class because it provided me with great deal of information that I need for the career path I currently taking. This class will make students ready for the real world jobs I recommend this class for anyone that is interested in networking and computers overall. In addition to that, I would like to thank Prof. Vigs Chandra for great way of teaching the class, always giving helpful comments to improve students capability.

Figure 13. Student comments noting the amount of relevant information (and practical hands-on skills) learned.

Making the time to create notes based on readings and review these regularly deliberately can be very helpful in establishing and retaining core content. The following student comments from a follow-up course, Advanced Network Devices, noted that switching to "*using mostly hand written notes …. Having them physically beside me was helpful through the semester when I needed to refer back to them.*" Even though the resources in that class are primarily in electronic formats, the student had found the hand-written notes to be particularly useful.

While using roughly drawn visuals to aid memorization of textual information may seem strange at first glance, it is this very property that makes the technique powerful. The more personal the visual, however peculiar it may appear to anyone else, the stronger our learning connection is to the material. [16] claims that its very "strangeness is its strength."

Conclusions

The paper includes various techniques and suggestions for annotating technical notes, texts, and web pages in computer networking systems. These integrate the use of words, mathematical expressions, visuals such as icons, and symbols, allowing the reader to interact with technical documents in a much more meaningful way than by merely skimming through the content. It invites students to make associations between the readings and their personal experiences, linking the text to the world around them, to their social network, and to other portions of the book itself. This multi-dimensional way of reading can be immensely helpful as we try to encourage students to create technological solutions for systems that may not even currently exist.

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