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Learning Out Loud (LOL): How Comics Can Develop the Communication and Critical Thinking Abilities of Engineering Students

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Learning Out Loud (LOL): How Comics Can Develop the Communication and Critical Thinking Skills of Engineering Students

Boredom is a significant issue in higher education.

--Rosegard and Wilson (2013)[25], p. 1

Because attention is the main gatekeeper to processing, storing, and retrieving information, learning cannot proceed in its absence.

--Wei, Wang, and Klausner (2012)[33], p. 7

Previous studies and our own experiences in the classroom suggest that images and humor can attract undergraduate students' attention, promote discussion, and improve comprehension of complex concepts. Here we investigate possible explanations for the power of images—in particular, one-frame cartoons and short comic strips—in helping engineering students not only to learn course content, but also to develop communication and critical thinking skills.

As Rosegard and Wilson (2013) document in "Capturing Students' Attention: An Empirical Study," boredom is a "significant and widespread academic emotion," much more prevalent than anxiety, anger, or hopelessness (p. 1).[25] Studies show that 39.2% of first-year students felt bored in the classroom in 2010 (weighted national norm), with 59.0% of all university students reporting boredom at some point while 30.0% of them report feeling bored most or all of the time (Rosegard and Wilson, 2013, p. 1).[25] From an educational point of view, boredom is not just unfortunate: it impedes learning because it diminishes motivation, information processing, and memory.

The elimination of boredom and the stimulation of interest are universal challenges for teachers regardless of the subjects they teach, the ages of their students, or the individual interests of their students. Overcoming these challenges can seem particularly difficult, however, in the case of engineering students taking science, technology, and society (STS) and other humanities and social science (HSS) courses (referred to as STS/HSS in this paper). The students are usually taking such courses to meet requirements rather than to satisfy their own curiosity. The STS/HSS courses are very different from their science, technology, engineering, and math (STEM) courses and may be perceived as irrelevant or boring, or both. These hurdles can easily become roadblocks to engagement for the majority of engineering students who are relatively inexperienced in the kind of analysis and interpretation that STS/HSS courses require. In other words, the sense that "I don't want to" is greatly intensified by the belief that "I don't think I can."

The approach to student engagement that we describe here—like many others developed by STS/HSS professors teaching engineering students—was developed intuitively by author Wylie when she was confronted by an all-too-familiar situation: facing a lot of open laptops and very little class preparation or participation in an introductory STS lecture class of STEM students who were mostly freshmen, many first-generation college students, and many English language learners. In response to the students' inability or unwillingness to read the assigned sources, she

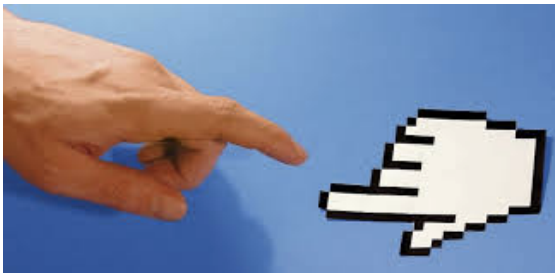
began asking them to interpret cartoons during class that reflected issues relevant to the day's lecture topic. The students were much more willing to discuss something that they had all experienced together, rather than something they had read (or not read) beforehand alone.

Moreover, the process of group interpretation of cartoons (what we call here "learning out loud") created a safe space where students could generate multiple plausible interpretations, as opposed to searching for a single right answer. When Wylie used the same approach with well-prepared and motivated students at another institution, she found that LOL worked equally well. In other words, the same images that were thought-provoking and helpful and easy to understand for low-achieving students were also thought-provoking and helpful and easy to understand for high-achieving students. That insight motivated the research question this paper attempts to answer: how does the literature on boredom, interest, and learning help explain *why* the pedagogical approach described here works? Based on published studies and our own informal pilot study, we provide a framework for the effective adaptation of learning from cartoons in a variety of educational contexts, with special attention to engineering education.

Section 1: Developing LOL as a Teaching Method

Learning (and laughing) out loud was inspired by desperation. Wylie had just begun her first teaching position as a lecturer at a STEM-focused university, where she faced a tough crowd of students. These mostly-freshmen undergraduates were largely uninterested and even hostile to the forced requirement of her large introductory STS course. At the same time, they were significantly less skilled at reading and writing than Wylie had anticipated. Their open laptops, poor attendance, missing assignments, and silence in response to her discussion questions were perhaps all signs of their intimidation at this foreign subject, which may have heightened or created their resistance to learning about it. In response to students' inability or unwillingness to read the assigned sources – a widespread cause of poor class discussions – Wylie began showing cartoons about issues relevant to the day's lecture topic. After all, cartoons demand only basic literacy skills, require no homework preparation, are fun and silly, and yet nonetheless manage to communicate complex and relatively open-ended meanings.

Before class began, Wylie would project a PowerPoint slide of 2-4 cartoons relevant to the day's topic, much as Cheesman (2006) describes.[5] As students arrived, they would read the slide and often react, with a smile or a groan or a look of confusion. To start class, Wylie would ask the class about each comic, "What is this author's message?", "How do you know?", "Why is it funny? Or why is it not funny?". She was surprised at the variety of interpretations, which thankfully made for interesting discussions and even debates about a cartoon's meaning. For example, Wylie showed this image on the first day of the large introductory class, to introduce the idea of the interactions between science, technology, and society:



A few students said it was a joke about the famous Renaissance painting showing God reaching out to Adam, but that God was replaced by technology, symbolized by a computer mouse-tracker hand. Other students said it was about artificial intelligence, that computers could act like humans or maybe like God. Interestingly, some students with that interpretation said that the author was portraying technology as bad, that it shouldn't "play God", while others thought the author was celebrating technology for its power. This is the educational value of interpreting comics: they are entertaining yet require interpretation; they play off familiar social norms and pop culture that students understand yet often convey generalized messages; and their meaning is not as clearly defined as most texts. Instead, cartoons make the viewer think, by being playful and open-ended. Students weren't afraid of suggesting a "wrong" answer, because all they had to do was make an argument for why their interpretation was plausible rather than "correct". This cartoon generated similar debates about technology as "cool" and impressive vs. as scary and overreaching:

These debates were friendly and often included laughter, as students tried to articulate the usually-unspoken reasons for why things are funny (or not), and what a cartoon author's perspective was. The humor and relative lack of explanation included in cartoons made it a low-

stakes, relaxed activity that required no preparation, minimal reading skills, and often an open mind and ability to think outside the box. The resulting animated class discussions were a relief and a joy, and students seemed to remember concepts better after discussing them via a cartoon. Also, analyzing cartoons at the beginning of class tended to get the most attention of the whole class time, because students would look up to see why others were laughing. But the mechanisms behind LOL were not clear. In this paper, we investigate previous studies on *how* comics can engage students' attention and on *what* skills LOL can help students develop, such as text analysis, perspective-shifting, and community-building.

Section 2: *How* and *Why* Cartoons Can Improve Learning: Research to Date

Many researchers in the learning sciences[1] note that the mental processes involved in attention and learning—concepts such as boredom, interest, curiosity, attention, arousal, and humor—are, as Rosegard and Wilson (2013) put it, "difficult to define" and "complex in function" (p. 2).[25] Given this ambiguity, it is not surprising that empirical evidence about these states and behaviors is scant and hard to collect. Nevertheless, it is possible to develop an understanding of underlying mechanisms and cause-effect relationships that explain *how* and *why* cartoons, as a combination of humor and images, might facilitate learning. More specifically, if we want to use comics to improve learning by decreasing boredom, we need a detailed understanding of the physiological and psychological processes involved.

The anatomy (and a partial defense) of boredom

As Toohey points out in *Boredom: A Lively History* (2011), "boredom is one of the most unexpectedly common of all human emotions" (p. 1).[30] "What makes something boring? Predictability, monotony, and confinement are key" (Toohey, 2011, p. 8).[26] Vogel-Walcutt, Fiorella, Carper, and Schatz (2012) provide a more technical definition of boredom as a combination of an objective, neurological state of low arousal plus a subjective, aversive psychological state of dissatisfaction, frustration, or disinterest (p. 102).[32] Goetz, Frenzel, Hall, Nett, Pekrun, and Lipnevich (2014) describe boredom as a heterogeneous, multifaceted experience consisting of

- Affective components (unpleasant, aversive feelings);
- Cognitive components (altered perceptions of time);
- Physiological components (reduced arousal);
- Expressive components (facial, vocal, and postural expression); and
- Motivational components (motivation to change or leave the situation) (p. 402).[9]

These varied definitions and the multiple factors included in them reflect the heterogeneous, complex nature of boredom and explain why it would be challenging to study empirically. One of the most promising developments in the field is "a theoretical model consisting of multiple boredom types [that] may better reflect individuals' actual experience of this emotion in

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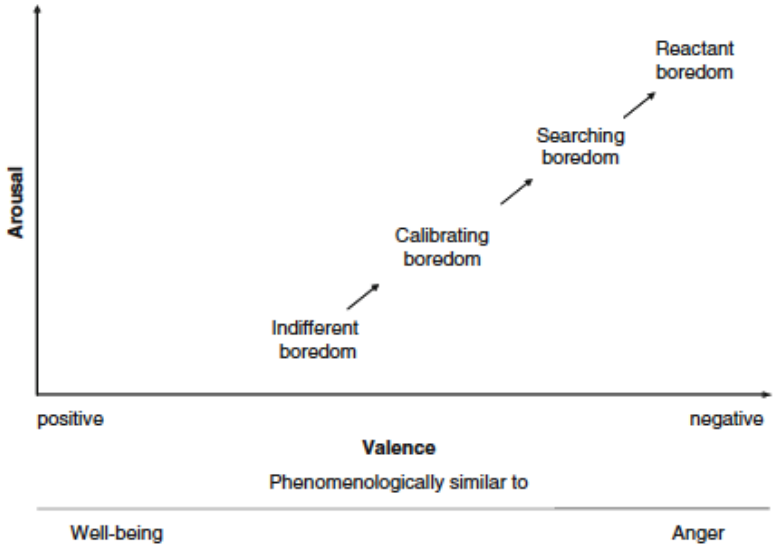
[1] According to the International Society for the Learning Sciences (ISLS, www.isls.org), the term "learning sciences" combines a number of disciplines including cognitive science, educational psychology, computer science, anthropology, sociology, information sciences, neurosciences, education, design studies, and instructional design. The research program of the learning sciences focuses on "the interdisciplinary empirical investigation of learning as it exists in real-world setting and to how learning may be facilitated both with and without technology."

everyday life" (Goetz et al., 2014, p. 402).[9] The figure below locates four different kinds of boredom relative to both the intensity of arousal present and the extent to which each particular kind of boredom is associated with negative affect (emotion).

Fig. 1 Localization of boredom types relative to negative valence and arousal (adapted from Goetz and Frenzel 2006)



Reporting on an interview with Goetz, Pappas describes the different kinds of boredom, which range from "dull and slothful to restless and irritable. Indifferent boredom combines a low level of arousal with a slightly positive emotion. It might be described as "relaxed and fatigued-but-cheerful" and results in withdrawal from the world (2013).[20] Calibrating boredom is a little more negative and a little more aroused. "People in this state want to do something, but that don't know what." Their attention wanders, but they are not motivated to search for alternatives that might eliminate the boredom. "Searching boredom is marked by much more active looking for something to do," such as hobbies or other activities. Reactant boredom can be described as an "antsy desire to escape." It is more intense than the other types: "People in this state feel very unhappy, even angry or aggressive. Imagine being trapped in a lecture hall listening to someone drone on about a dull topic for hours on end" (Pappas, 2013).[20] A fifth type of boredom called "apathetic boredom" by Goetz and colleagues (2014) combines the worst of both worlds: a low state of arousal and a neutral (neither positive nor negative) affective state. Apathetic boredom seems to *discourage* motivated behavior such as learning. It is perhaps most similar to "learned helplessness or depression" (p. 414).[9]

In their own experimental work with high school and university students, Goetz and colleagues provide further evidence to support the theory that boredom has very different consequences in achievement settings (like classrooms) compared with non-achievement settings (like shopping) (2014, p. 404).[9] They continue, "Of particular concern is the relative frequency of *apathetic* boredom observed in the present research" with respect to both university and high school students in achievement settings (p. 414).[9] This finding may be particularly significant for STS courses for engineers, which students may perceive as unfamiliar and threatening, if only because these courses question assumptions about the roles of science and technology in human experience.

In any case, in an educational setting, the effects of boredom seem fairly clear: an aversive psychological state plus suboptimal arousal leads to decreased engagement and motivation to learn. On the other hand, "if there is sufficient arousal, attention to the stimulus allows cognitive processing of the stimulus resulting in the forming and storing of memory" (Rosegard and Wilson, 2013, p. 2, citing Wei, Wang, and Klausner, 2012).[25, 33] Toohey states the implications of this point directly: The simplest of all methods [for alleviating boredom] is doubtless what a grandmother would prescribe: variety of experience" (2011, p. 175).[30] This recommendation has particularly relevance for all instruction, including the use of comics in STS courses: variety is essential.

Arousal, curiosity, and interest

The most fundamental concept in the research on attention and learning is arousal. In common usage, it is roughly equivalent to waking (as from sleep) or kindling (as in building a fire). Arousal is the first stage in a process that generates and sustains what we generally refer to as "paying attention." The attention-getting techniques recommended to teachers, variously termed "hooks," "attention-getters," "triggers," and "anticipatory sets," are all external stimuli designed to heighten arousal, which "underlies all motivated behavioral responses, cognitive functions, and emotional expression" (Pfaff, Ribeiro, Matthews, and Kow, 2008, p. 11).[21]

Rosegard and Wilson (2013, p. 2)[25] point out that arousal, like boredom, has both physiological and psychological elements. In the process of arousal, sensory input (a stimulus) is processed by the brain's limbic system[2] and both activates and regulates numerous mechanisms including attention and memory. Moderate arousal appears to be optimal: too much arousal creates anxiety, and too little creates boredom. In this context, "moderate" is a rather fuzzy concept that cannot be quantified easily and, like virtue, would vary depending on circumstances.

Anxiety	Curiosity and Interest	Boredom
Too much arousal	Moderate arousal	Too little arousal

Curiosity is "a basic biological drive and motive for learning" (Rosegard and Wilson, 2013, p. 3).[21] It is increased by novelty, incongruity, ambiguity, and surprise (which are collectively referred to as "collative properties"). It is decreased by stimuli that are familiar, simple, clear, and expected. In the case of comics, we would expect that they would spark students' curiosity to the extent that they are novel, incongruous, ambiguous, and surprising.

Interest is a particular type of curiosity and consists of two different types: individual and situational. Individual interest focuses on a particular area or activity and evolves over time through sustained cognitive and affective processing. Instructional strategies may draw on individual interest but cannot create it directly or quickly. Situational interest is what we are usually talking about when we discuss attention-getting devices and strategies. It originates from a specific object, activity, or event and focuses an individual's attention. Situational interest is *stimulated* by novelty and *maintained* by relevance and meaningfulness. In other words, novelty and challenge, at the right level and presented properly, increase situational interest, which then

2 The limbic system is sometimes called the "paleomammalian brain" on the theory that it is older than other parts of the brain and home to "fight or flight" behaviors.

produces the cognitive processing that we call "attention." To the extent that they present novelty and challenge, comics have the potential to create situational interest.

Attention

Rosegard and Wilson argue that attention is "the main gatekeeper to processing, storing, and retrieving information" (2013, p. 5).[25] It is not surprising, then, that teachers should be so interested in devices that can focus students' attention on class content (p. 4).[25] The research on attention offers few surprises but does provide a usefully refined description of the underlying processes and variables that are involved. In the simplest terms, the bottom line of this research is that people who pay attention remember more. The process by which increased arousal leads to attention and increased memory has been studied by many researchers. The consensus emerging from that research and summarized by Rosegard and Wilson (2013, pp. 4-5)[25] is shown diagrammatically below.

***Increased* arousal.**
Leads to
Narrowed attention and restricting the number of cues processed
Which results in
Increased attention to and retention of material

On the other hand,

***Decreased* or *deficient* arousal**
Leads to
Wider attention and a larger number of cues processed
Which results in
Wandering attention, distraction by competing stimuli, and less retention of material.

In other words, the right level of arousal helps the learner prioritize stimuli effectively.

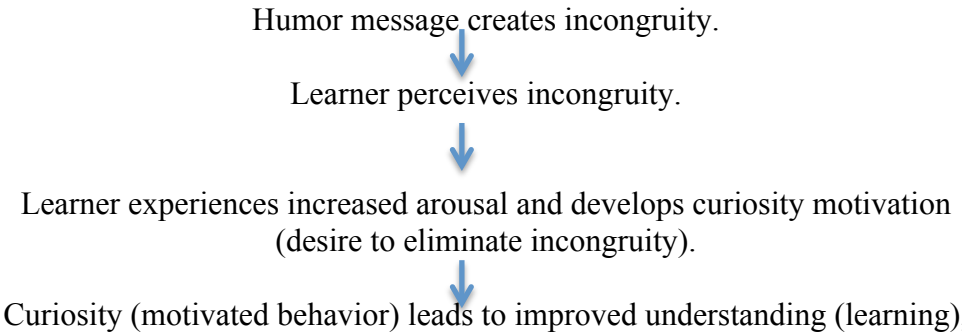
Drawing on the work of Mather and Sutherland (2011)[15], Rosegard and Wilson identify two distinct but interdependent kinds of prioritization, both of which can occur in the presentation and discussion of comics. *Top-down prioritization* is cognitively based and goal relevant. It includes strategies such as asking a question that draws on students' prior knowledge or explicitly stating desired outcomes. *Bottom-up prioritization* is emotionally based and perceptually salient. It includes strategies such as presenting a disturbing video or photograph, a contradictory statement, or a powerful statistic. Comics initiate bottom-up prioritization simply by being presented. They initiate top-down prioritization as they are interpreted and discussed with the guidance of the instructor.

As the foregoing explanations make clear, arousal and attention come before learning and memory and modulate the processes involved. Learning and memory are closely related but distinct processes. "Memory" refers to the processes by which stimuli are encoded, stored, consolidated, and recalled. Learning entails an additional process: subsequent behavior change. This distinction is important for the use of comics in an instructional setting because it can spur

instructors to identify the ways in which students might change subsequent behavior as a result of recalling what they learned through interpreting the comic.

Humor and images: two categories of external stimulus

Rosegard and Wilson (2013, drawing on the work of Martin [2007][16]) identify three characteristics that define humor and apply to comics: (1) verbal or nonverbal communication, (2) positive emotions, and (3) incongruous meanings (p. 6).[25] The incongruous meanings are resolved through an interaction between physiological arousal and cognitive appraisal that results in learning. The sequence of events is this:



From a theoretical perspective, then, the successful use of humor depends on (a) the humor message capturing the attention of the learner and being relevant and appropriate, and (b) the learner resolving the incongruity in the humor message. Empirical research into the instructional value of humor, however, has yielded inconsistent results, largely because learning is an emergent property that results from the interaction of the many factors at work in any classroom. Some of these are under the instructor's control, but many are not. Add in individual differences among learners and the difficulty of clearly distinguishing between dependent and independent variables, and the challenges of empirical research in this area become even clearer.

Because they combine verbal and visual stimuli, comics fall into the category of multimedia messages. Unlike the research into the instructional value of humor, research into multimedia messages has produced results that are *both* positive and consistent. Multimedia messages elevate arousal, focus attention, and enhance learning (Rosegard and Wilson, 2013, p. 7).[25] More than one mode of presentation leads to more learning. According to the Cognitive Theory of Multimedia Learning, auditory and visual stimuli are processed separately but operate in parallel in working memory, which means that there is more access to cognitive capacity to process information presented in both text and pictures.

There have also been some interesting studies of the humor effect in an academic context, particularly when the subject to be learned is perceived as difficult. In "The Effects of Humor Cartoons in a series of Bestselling Academic Books" (2014)[23], Piaw describes research he conducted in connection with a series of research and statistics reference books in which he used humorous cartoons as a key element of his explanatory strategy. Both the literature review he provides and the experimental results he obtained provide a rationale for using that particular explanatory strategy.

In some respects, the themes Piaw identifies recapitulate what has already been presented in this paper. That is, humor helps learning by increasing intrinsic motivation, aiding memory, improving comprehension, increasing attention span, and increasing retention. But Piaw also establishes some new dimensions of the function of humor, especially in difficult subjects: diminishing tension and stress, reducing anxiety, creating an environment that is conducive to learning, and building rapport between writer and reader. The cascade of effects appears to work something like this:

Increases receptiveness to alarming or difficult material
Which in turn
A sense of openness in the learner,
Which fosters a sense of openness in the learner

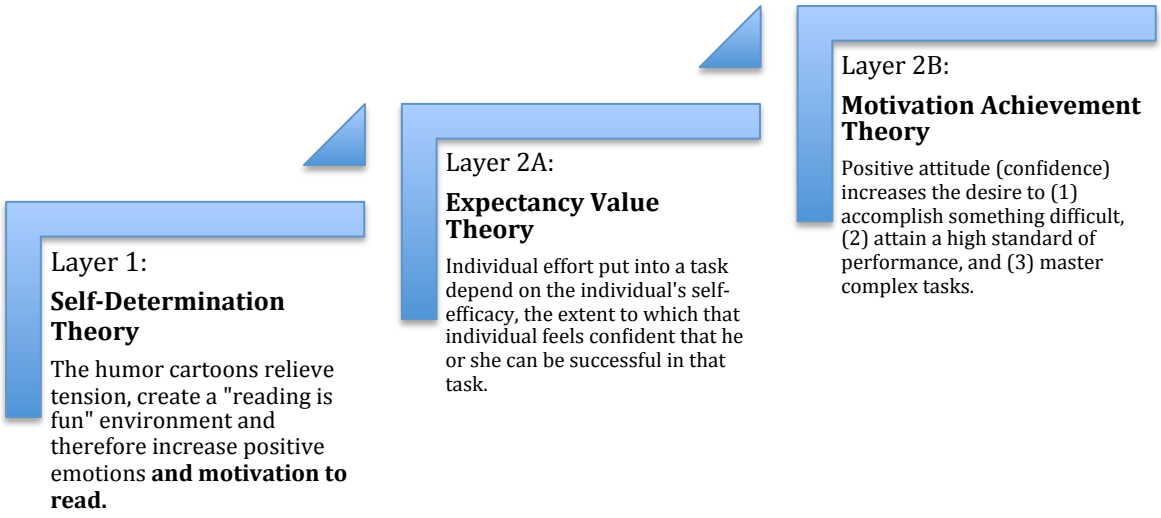
Two theories help explain why humor has these effects. The first is Toughness Theory, which holds that "humor-conditioned subjects are ready to undertake more challenging studying activities" (Piaw, 2014, p. 500).[23] The underlying mechanism is that humor increases energy without increasing tension, which leads to increased willingness to study hard material. The second theory is the Relief Theory of Laughter, which is based on Freud's Humor Relief Theory. According to this theory, an encounter with humor releases positive energy, which increases motivation. Motivation, in turn, creates a perception that learning is fun and alleviates boredom.

Piaw defines motivation as a "multifaceted set of goals and beliefs that guide behavior" (Guthrie and Wigfield, 1999, p. 99, as cited in Piaw, 2014, p. 510).[23] To assess the role of humor cartoons in increasing motivation, Piaw conducted an experiment in which subjects were given two different versions of a chapter: (1) a text-only version and (2) a text with humor cartoons. The main conclusions emerging from the experiment were that "Reading the text with humor cartoons led to great self-efficacy, intrinsic and social motivation [and thus] help a reader to achieve a higher reading comprehension score" (Piaw, 2014, p. 513).[23] One way to interpret these findings is that humor enhances reading motivation, and motivated readers invest more effort in reading. Another way to interpret these findings is to say that the humor cartoons increased the satisfaction readers experienced. Satisfaction derives from a number of factors:

1. Ability to master complex ideas
2. Willingness to learn difficult things through reading
3. Strengthened belief in their ability to do well in reading and learning
4. Increased desire to learn (curiosity)
5. Enhanced sense that the reading material is important to the learner
6. Increased willingness to participate and learn (Piaw, 2014, p. 513)[23]

All of these factors would be relevant in the context of STS courses for engineers, where students might perceive many of the core ideas (such as social construction of technology or technological determinism) as complex and the course readings as difficult to understand. Thus, cartoons could perhaps strengthen students' belief that they are capable of reading and learning about STS concepts. To the extent that the interpretation of comics can promote curiosity (the increased desire to learn), it should, in turn, create an emotional space in which the learner perceives that the STS content is important to the learner—all of which should result in an increased willingness to participate and learn.

Piaw connects these results to a theoretical foundation with what he calls a "two-layer model" (2014, p. 515)[23], which is depicted graphically below.



In addition to comics' potential to improve students' motivation and attention through novelty and incongruity, we suspect that discussing comics together in class also contributes to students' participation and therefore comprehension. Although cartoons expect certain cultural and background knowledge from their viewers, their reliance on images makes their messages more open-ended than most text-only sources that students typically encounter in classes. This collective analysis of ambiguous sources may engage students' sense of creativity and ability to take different perspectives, encouraging them to think outside the box and beyond the literal message. This activity also encourages open-mindedness and willingness to entertain and evaluate a variety of explanations proposed by different readers. We have not found studies of this phenomenon, which deserves scholarly attention to learn how students react to interpreting a source with multiple plausible meanings. Cartoons offer a good platform for studying students' development of social, analytical, and communication skills through group interpretation of a source with subtle and multiple meanings but also with humor. We suspect that this low-stakes analysis of humorous, silly cultural artifacts in particular can encourage classroom community-building, because "good" interpretations are judged by their promoters' arguments rather than by their "truth" and because cartoons promote a relaxed, fun environment of collaboration rather than competing to give the right answers. Cheesman, who uses cartoons consistently to engage, inform, and evaluate students in her undergraduate biology classes, observed that cartoons broke down barriers and promoted connections in her classes: "Students who like the comics appreciate that you are doing something for them, and those who think your sense of humor is warped are still establishing a more personal relationship that can only help foster a climate of learning within the classroom" (2006, p. 48).[5] A climate of learning, therefore is one that encourages students' attention, motivation, and participation.

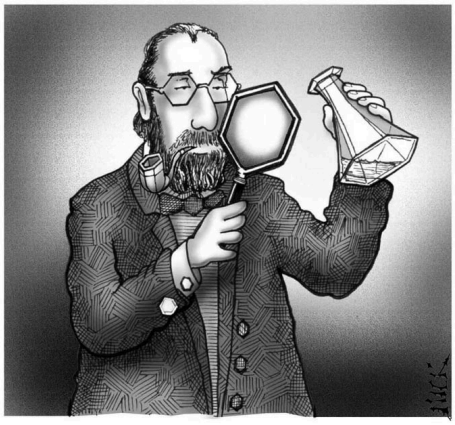
Section 3: Cartoons as Cultural Symbols

In addition to their ability to engage and energize students, cartoons are symbolic texts that require interpretation based on cultural awareness and critical thinking. Interpreting cartoons is therefore a valuable educational exercise, not just an attention-grabbing hook or mindless entertainment. It crucially relies on skills that ABET values for engineering students, such as considering multiple perspectives and thinking about social contexts. When cartoons are analyzed aloud during class, as discussed above, then students also practice oral communication skills, including defining an explanation and listening with an open mind to others' interpretations.

Like all sources, cartoons are multi-layered and constructed to convey an author's message. Barthes' (1977)[1] classic article "Rhetoric of the Image" dissects the many components of meaning embedded in one simple-seeming advertisement, based on its few words of text and images of its products. The advertisement, like a comic, is a "sign", meaning that it conveys a message to others in the same culture. Signs can be words, images, actions, or objects. Regardless of their form, signs, according to linguist Ferdinand de Saussure ([1916] 1973)[26], include both literal messages (signifiers) and implied messages (signifieds). Signs vary by culture and are encoded with cultural understanding, especially in their signified meanings, which the viewer must decode according to social context because signifieds are not directly explained in the sign. In that sense, analyzing the meaning(s) of images (e.g., cartoon drawings) is comparable to analyzing texts (e.g., a peer-reviewed academic article). Both require the viewer to understand the exact words or depictions (signifiers) while also "reading between the lines" to interpret indirect meanings embedded in the sign. Signifieds, for example, can include sarcasm, irony, absurdity, double entendre, or other implied meanings. These meanings can only be understood through the reader's awareness both of the social context and of the fact that the signifiers are not intended to stand alone.

Signs are only interpretable with knowledge of social context; cartoons therefore require viewers to understand the norms and debates in the society in which the signs were created. Roseky and Kennepol (2008, p. 1356)[24] discuss the subject-specific signifieds of chemistry cartoons, such as this one by Nick Kim:

Great events in Chemistry...



1865: Kekulé, moments before his brilliant insight into the structure of benzene.

Students must be able to read the words and identify the pictures in the cartoon (signifiers), but also recognize the implied signified concepts of what benzene is and what Kekule discovered about it (i.e., its hexagonal ring structure). Only then does it become comprehensible why Kekule is surrounded by hexagons in this cartoon. Asking students to identify the cartoon's underlying meaning would reveal whether they know the structure of benzene. Cartoons' meanings are so dependent on a viewer's background knowledge and cultural awareness that they can be used as evaluation tools (Cheesman, 2006).[5] Concept cartoons, for example, try to make science clearer by using cartoons' narrative structure to frame a concept in terms of familiar experiences for elementary-school students, as in Figure 2 (Keogh and Naylor, 1999, p. 433).[14]

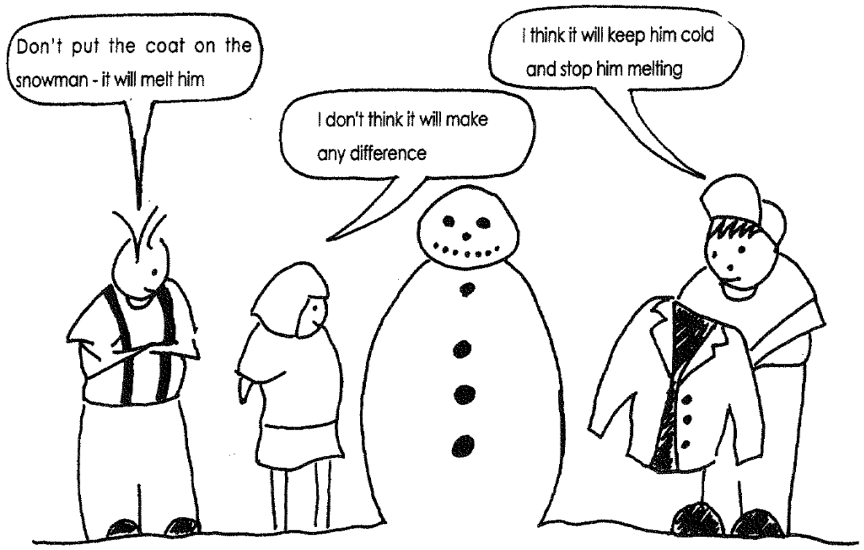


Figure 1. From Keogh and Naylor (1997).

Concept cartoons present multiple interpretations of science to help young students identify and challenge their misconceptions. The signified in this cartoon may be that it is silly to put a coat on a snowman; we build them with carrot noses and stick arms but not with coats. That incongruent cultural practice should call students' attention to the correct response depicted in the cartoon, encouraging them to think about why we might wear coats and why we don't put them on snowmen. Perhaps political cartoons are the most evident example of cartoons' reliance on the viewer's awareness of current events, social debates, and even stereotypes common to the society in which the cartoon was made. Political cartoons are unusual cartoons because they arguably reflect as well as influence a society's beliefs, in their roles as neutral social commentary or as propaganda intended to promote a certain outcome (Mills et al., 2013, p. 183).[17] As a result, political cartoons are often used in educational activities to teach students textual analysis and interpretation skills as well as content information included in the cartoons, such as political science, history, and ethics. Learning how to "read between the lines" and decode the signifieds in signs all around them is a crucial skill for engineering students, and one that ABET encourages in its requirements that students "think critically about and reflect on the processes of problem definition" and receive "the broad education necessary to understand the significance of engineering solutions in a global and social context."

Cartoons rely on visual messages, sometimes combined with simple text. Visual signs can require different skills to decode than texts, such as cultural awareness, irony, and the ability to

consider multiple points of view. Crucially, interpreting visual messages relies less on reading skills, thus enabling students with low literacy to practice interpreting sources without the barrier of difficult text. Bolton-Gray suggested why cartoons can improve students' access to complex ideas: "This type of dual processing, emotional (humor) and visual (pictures/text), can help level the playing field for students trying to accommodate abstract content" (2012, p. 390).[2] Analyzing cartoons can draw on and value different skills than are emphasized in typical classes, such as image interpretation, aesthetic awareness, and knowledge of pop culture. This focus can improve class experience and access to course content for under-engaged students who may perform better at these skills than at more traditional academic skills such as reading. The benefits of this broader-access approach are evident in the widespread use of cartoons to teach young children, whose reading skills are developing and vary widely within a class (e.g., Bowkett, 2011)[3], and English language learners (e.g., Cary, 2004).[4] Educators also value cartoons for students with disabilities, partly because many students can interpret pictures more easily than words and partly because the pictures are full of social meaning that students with social interaction disabilities such as autism find difficult to understand (Wellman et al., 2002[34]; Kana et al., 2006[12]). Cartoons are so socially-encoded that teachers use them to help students with disabilities learn the cultural, emotional, and implied messages that they have not picked up from the process of socialization (e.g., Gray, 1994).[10] But we have not found research on the role of cartoons in adapting undergraduate courses for students with low literacy, whether due to disability or inadequate preparation for college.

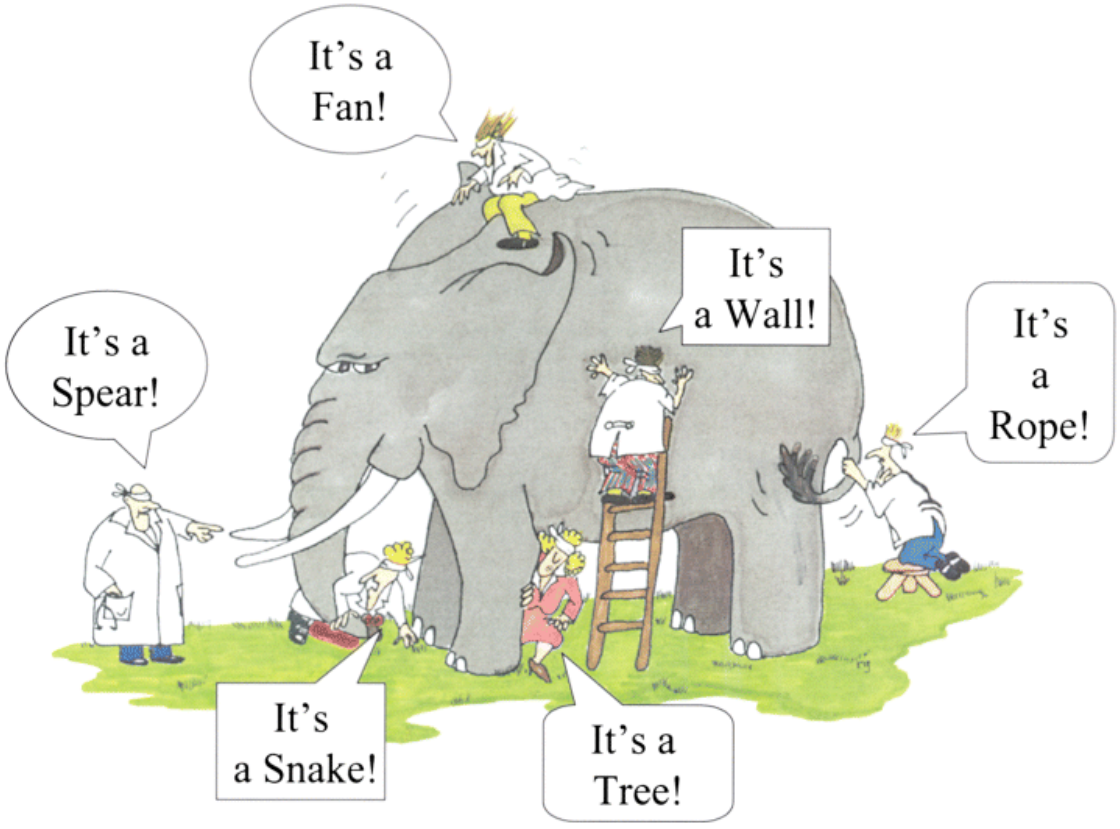
Cartoons offer productive educational activities because, as cultural symbols, they require interpretation, and because, as paired images and texts, they suggest multiple possible interpretations and give low-literacy students an opportunity to practice their analytical skills and creativity. More studies are needed to elucidate the mechanism of cartoons' impact on students' ability to interpret signs (i.e., images as well as traditional texts) based on their cultural and academic knowledge. Accordingly, we need more research to show how we as engineering educators can better employ communal interpretation of texts and images to help students develop their textual analysis skills, social and cultural awareness, and communication skills. Cartoons show great promise of being an easy, entertaining, and effective way to help students build these elusive and challenging abilities.

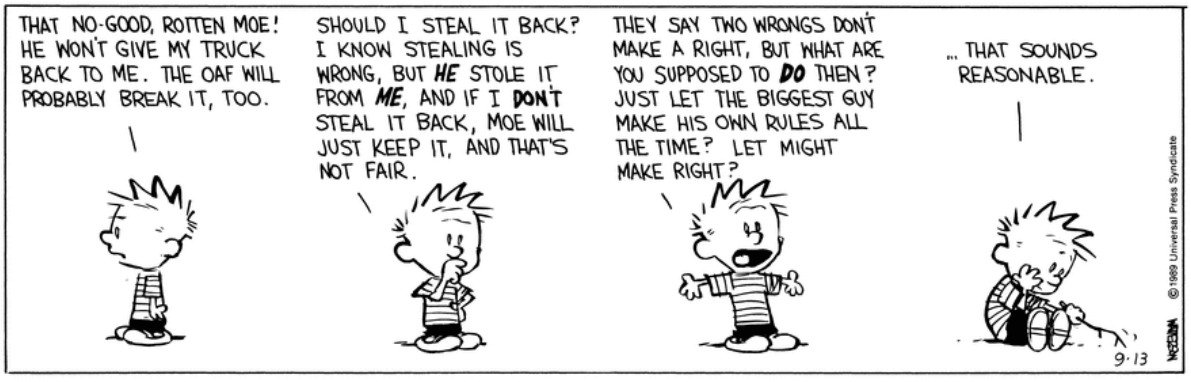
Section 5: A Pilot Study

In January 2016, we conducted a pilot study to investigate potential effects of LOL with cartoons in STS courses for engineering students. Because this is a localized study of the effectiveness of our own teaching methods, we do not need IRB approval. Each of us designed our own lesson plan (i.e., lecture, case studies, and discussion) about ethical theories for four sections of a senior-level course that includes engineering ethics. We assessed about 120 students, all majoring in engineering. Two sections' lesson plans included cartoons, which the instructor explicitly led a discussion about and linked to the ethical theories. The other two sections did not see or discuss cartoons. At the end of the class, all the students anonymously took a short multiple-choice assessment (see Appendix). Neeley then revealed and discussed the answers to the assessment with her classes; Wylie did not reveal or discuss the answers. Then all the classes spent seven weeks studying other topics and did not discuss engineering ethics. In March 2016,

the students took the assessment again as a measure of longer-term retention, which some studies found to be improved by relevant humor and images (e.g., Kaplan and Pascoe, 1977).[13] We hypothesized that students in the cartoon sections will better remember and understand the theories in both the short and long term than their peers in the no-cartoon sections.

Pilot study cartoons





Results

Our results echoed previous studies' ambiguous findings, upholding the belief that both learning and studying learning are complex processes. In Wylie's classes, the initial assessment scores were comparable but slightly higher for the class that did not see or discuss the cartoons. In Neeley's classes, scores were much higher (by 11%) for the class that did not see or discuss the

cartoons. These surprising results suggest that cartoons do not improve students' immediate understanding of complex ideas, based on the assessment taken at the end of the class period.

First Assessment (immediate)		
	Classes shown cartoons: % correct (average score)	Classes not shown cartoons: % correct (average score)
Wylie's students	71.6	74.5
Neeley's students	72.3	83.3

On the second assessment, taken seven weeks after the first, both classes who viewed cartoons *forgot less* than the classes who did not view cartoons. There was no explicit instruction on the assessment's topics in the intervening seven weeks, except when Neeley discussed the assessment's answers with her classes immediately after the first assessment. This discussion most likely explains the striking improvement in her students' scores who had seen the cartoons (a 19.3% increase) and the low level of decrease in her students' scores who had not seen the cartoons (-1.6%). Neeley's students remembered the information better than Wylie's students, who were not told the answers or asked to reflect on the assessment. Wylie's classes earned similar scores on the second assessment (64.8% and 65%), but the class that viewed cartoons still forgot slightly less than the class that did not view cartoons, as shown by the percent change in scores between the first and second assessments. That class's score fell by only 6.8%, while the cartoon-less class's score fell by 9.5%.

Second Assessment (seven weeks later)		
	Classes shown cartoons: % correct (average score)	Classes not shown cartoons: % correct (average score)
Wylie's students	64.8	65.0
Neeley's students	91.6	81.7

Percent change between average quiz scores		
	Classes shown cartoons: % correct	Classes not shown cartoons: % correct
Wylie's students	-6.8	-9.5
Neeley's students	+19.3	-1.6

Conclusion

There are of course innumerable variables in a classroom setting, and we believe that this pilot study provides data that partially capture the powerful theoretical justification for LOL. The students who saw the cartoons scored lower on the immediate assessment than students who did not see cartoons, which surprised us. It's possible that without the cartoons, we as instructors stated the lecture information more directly, as opposed to letting students argue and discuss

what the cartoons meant. While these discussions probably qualitatively improved students' engagement, the variety of proposed interpretations could have confused students about the accurate meaning of ethical theories.

Our classes' scores on the second assessment suggest that cartoons can improve retention of students' understanding of complex ideas. One cartoon-viewing class (Wylie's) remembered more than the non-cartoon-viewing class, though only slightly. The other cartoon-viewing class (Neeley's) showed a striking increase between their first and second assessment scores. We suggest that this improvement stems from the class's discussion of the assessment's answers, but Neeley's non-cartoon-viewing class had the same discussion and yet showed a small fall in their scores. This discrepancy suggests that viewing and discussing cartoons may have helped students retain the assessed information, and even more so if answers are discussed after the first assessment. How to effectively deploy cartoons as learning objects and as sources of productive discussion deserves more research for the community of engineering educators.

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Appendix: Pilot Study Assessment

1) Which ethical theory is based on the ideas of Aristotle?
   a) Utilitarianism
   b) Virtue ethics
   c) Rule-based ethics
   d) Rights-based ethics
   e) Pragmatism
2) "Ethics is a fundamentally social enterprise." Choose the statement that is *consistent* with this idea.
   a) The social consequences of an act or decision matter more than the reasons given to justify that act or decision.
   b) Communication is a central activity in developing ethical principles and making ethical decisions.
   c) Groups develop goals and shared notions of acceptable behavior through a competitive process dominated by people who aggressively argue their point of view.
   d) Individual autonomy (the capacity for individuals to be self-determining in their beliefs) has no place in ethical analysis and deliberation.
   e) Achieving the greatest good for the greatest number is the goal of ethical decision-making.
3) An ethical environment is:
   a) Often present but sometimes absent.
   b) A guarantee against conflict and disagreement.
   c) Always present but often not made explicit.
   d) More often found in organizations where the majority of people are religious.
   e) Influential in shaping personal decisions but not organizational decisions.
4) Which of the following statements explains why having a sense of what is "right," "wrong," and "fair" is essential but not adequate for reaching ethical judgments about possible courses of action?
   a) Everyone has a different idea about what is "right," "wrong," and "fair."
   b) If we can just get enough information, the ethical course of action will become obvious.
   c) In some circumstances, *all* of our options seem unsatisfactory, but we still have to make a choice about what to do.
   d) We also have to choose a superior mode of ethical analysis (i.e., ethical theory) for a particular decision.
   e) Polls can tell us how people will respond to a particular decision, and we can use that information to make a decision.
5) The relationship between rights and duties is:
   a) Reciprocal: no right can exist unless there is a corresponding duty to respect it.
   b) Unequal: rights matter more than duties.
   c) Hierarchical: people of lower socioeconomic status have more duties and fewer rights than do people of higher socioeconomic status.
   d) Inverse: people who focus too much on doing their duty won't have enough time and energy to look out for their own rights.
   e) All but a