

## Introduction

The field of engineering education has grown rapidly and with it, many questions have undergone successive iterations. One of these questions has been how to increase the rate of adoption of research-based theories and materials thus narrowing the 'Implementation Gap.' One popular approach has been to describe the problem in terms of how developers and potential adopters are different, or have different perspectives, which is often informed by Roger's Diffusion of Innovations theory (Rogers, 2008). For example, the PCAST report "Engage to Excel" (Olson & Riordan, 2012) defines the question in terms of knowledge and experiences many instructors lack. Defining the problem as a 'gap' suggests solutions that bring adopters and developers closer together, such as the commonly proposed practice of immersing instructors in the co-development of curricular materials (Henderson & Dancy, 2007). Through immersion, researchers aim to co-develop materials that are more relevant to their targeted audience, instructors. Little research has focused on this co-development effort between researchers and instructors though, and there is a lack of understanding about components that can help support or hinder these types of collaborations.

In this paper we propose and briefly explore the concept of 'storytelling' as one key component of any effort to bring developers and implementers closer. During any type of collaboration, whether it is during co-development, research, or learning, participants often utilize storytelling to convey meaning, inspire each other, and provide examples (Beckman & Barry, 2009). There is a plethora of research on storytelling (Adams et al., 2007; Beckman & Barry, 2009; Cheryl et al.; Kincal, Beypinmar, & Topçu, 2013; Langellier, 1989; Shank, 2006) but the research within higher education has mainly focused on storytelling as a pedagogical tool (Abrahamson, 1998; Alterio & McDrury, 2003; Andrews, Hull, & Donahue, 2009; Lordly, 2007; McDrury & Alterio, 2002) and for faculty development (Lowenthal, 2008). Specific to engineering education, storytelling has been examined as a way for researchers to create and sustain community (Adams et al., 2007). But a gap in knowledge exists surrounding the significance of storytelling in establishing meaningful adoption of curricular innovations.

## Literature Review

Storytelling is an age-old method of transmitting knowledge and traditions. Verbal stories are not relied on as heavily as they once were now that there is printed text. Despite this, stories still persist throughout society as means to convey one's own experiences to others. Though stories can be positioned within dialogue in a range of settings and situations, Langellier (Langellier, 1989) has identified five broad theoretical roles: *Story-text*, *Storytelling Performance*, *Conversational Interaction*, *Social Process*, and *Political Praxis* (Table 1). The five roles cover a range of scenarios in which stories are used to present oneself or position one's own anecdote over another.

Furthermore, storytelling has been utilized in higher education as a pedagogical tool (Abrahamson, 1998; Alterio & McDrury, 2003; Andrews et al., 2009; Lordly, 2007; McDrury & Alterio, 2002). Specifically, storytelling is linked to learning that is more meaningful and reduces depersonalization when used within an educational setting (Abrahamson, 1998). Lordly (2007) found in an undergraduate nutrition course that storytelling can have a positive influence on the learning environment. Additionally, Andrews et al. (2009) has summarized research that supports storytelling as effective for learning across multiple pedagogies.

Table 1. Langellier's Theoretical Roles of Storytelling

Theoretical Role	Summary
Story-text	Story from the past is recounted. The sequence of events remains in order. The audience does not play a role in the social context of analysis.
Storytelling Performance	The actor and listener share context and conventions. No longer focused on the dynamics of a text-centered approach but instead on the performance.
Conversational Interaction	The listeners play a larger role and are part of the construction of the stories being told. Stories are meaningful in the present and are connected to experiences and future possibilities.
Social Process	Stories allow for more input from the audience and are used to negotiate present and future events.
Political Praxis	The actor's own story is told from a position of power and knowledge. The story serves particular interests and mold social identities and perceptions.

Not only have stories been used as a pedagogical tool, they have been found to be used among teachers as a way of sharing their teaching experiences (Shank, 2006). Sharing of experiences (or storytelling) has also been shown to facilitate a collaborative space that revolves around creating and learning (Shank, 2006). Within a collaborative group setting of secondary teachers, it was shown that teachers learn from each other by first getting to know about the others' experiences in teaching methods (Meirink, Meijer, & Verloop, 2007). Additionally, it has been found that by sharing ideas and experiences (storytelling) during curriculum design, participants are able to challenge their own pedagogy (Dempster, Benfield, & Francis, 2012)

Demonstrated use of storytelling has also been found outside the classroom setting. In a corporate setting, focused on design and innovation (one of the objectives of the workshop that the current investigation is centered on), stories have been found to fall into two broad categories; those that inform the design process and those that inspire the design team (Beckman & Barry, 2009). Informative stories guide the analysis phase and include successes and failures while inspirational stories guide the synthesis phase and inspire creativity, aid in overcoming challenges, and facilitates connections to the customers (Beckman & Barry, 2009). Furthermore, in the field of engineering education, it has been suggested that storytelling is an effective way to build community and shared knowledge between researchers (Adams et al., 2007).

It is evident that stories are used to communicate in a variety of settings and by numerous people, including instructors. To summarize, storytelling has been shown to build community, create shared knowledge, challenge one's own pedagogy, facilitate collaborative learning and creativity, and reduce depersonalization, all aspects that would appear to prove beneficial during the co-development of materials. Therefore, this work seeks to investigate how storytelling is situated within the context of curriculum development that incorporates the potential implementers.

## Methods

A workshop was held in August of 2014 and spanned 1.5 days which focused on supporting instructors in developing new course materials. In total, 17 college level instructors participated from 14 universities across the Pacific Northwest region of the United States. Both 2-year and 4-year institutions were represented by the participants as well as private and public universities. The workshop participants were divided into five groups, each covering a specific content area within an undergraduate level Mechanics of Materials course (Axial loads, Bending loads, Limitations/Assumptions/Uncertainty, Stress and Strain Elements, and Torsional loads). The

groups' interactions during the workshop were audio recorded and these recordings were later transcribed and analyzed for other purposes. The prevalence and importance of storytelling in these interactions arose organically from the transcribed audio data and inspired the work reported here. The storytelling data presented here originated from the workshop transcripts that were then further analyzed and coded utilizing the constant comparative method (Glaser, 1965) and Langellier's (1989) theoretical roles of storytelling. In determining what would be counted as a story, the following definition was constructed:

*Anything told or recounted, a series of past events. Events can be implicitly implied when they are summarized as experiences, episodes or occurrences and presented as evidence or rhetorical devices.*

## Findings

The stories the participants told over the course of the workshop became increasingly interactive and relied more heavily on shared context and meaning. Their stories reveal a growth in connectedness and evolved over the span of the workshop.

The types of stories utilized throughout the workshop varied with the progression of the development of curricular materials. When groups were initially formed, a majority of the stories took the Storytelling Performance form. Participants all had prior experience with Mechanics of Materials' topics and therefore had a shared understanding of the content and vocabulary specific to teaching the course (a key element of Storytelling Performance). During this initial stage, participants were brainstorming different ideas surrounding the task at hand and in doing so, often told stories about what they currently do in their classroom and how it could be useful to addressing student misconceptions. For example, when one group was trying to decide on which misconception to address (they had been given the choice of three different ones) one of the participants recounted the following:

*Here is a good one, this is one that I use in class, which I think is a good example. I mean it really captures all three [previously researched student misconceptions] right. So you have this loading, you have a tube at the top and a solid member at the bottom and you have a load in the center and then it says determine the absolute maximum bending stress in the truss. So for the first misconception is your core point loads and support conditions. So it is a distributed load but close right. So where is the maximum bending gonna be? So it is here [pointing to location on drawing], can they do that? Can they conceptually put that together that it is here then calculate it with a section?*

None of the other group members questioned the meaning behind the terminology used such as 'loading,' 'solid member,' or 'maximum bending stress,' due to everyone in the group already possessing a socially agreed upon use of these conventions within the context of Mechanics of Materials. Additionally, though never directly stated, by telling this type of story early on during the group's interactions, this participant used stories to position himself as knowledgeable about the pertinent concepts and experienced within the classroom setting (another key element of Storytelling Performance, inferring meaning).

Although this example is not a conventional 'story' as we commonly use the term, it is a strong example of a Storytelling Performance (the second type in Table 1) because the speaker draws heavily on shared meaning and terminology to walk the audience through an example problem. The speaker conveys expectations of student performance and the significance of that performance. We note that this quote likely does not convey much to the readers, and that is part of its strength as an example: within this Storytelling Performance, the speaker related individual experience to the group and established a new group experience.

Again, we see during the initial stage of orientating oneself to the group and project the emergence of a Storytelling Performance story. In this particular occurrence, a participant was sharing with the group some simple, hands-on demonstrations:

*I want to show you a couple things. I also use chalk and I usually use tootsie rolls. So chalk is really good to show the different loads before combining them. So they [students] can all take a piece of chalk and put a bending moment on it, axial and torsion. What is interesting is to look at the planes where they break. So that brings a lot of ideas together. We also use a tootsie roll because it talks about ductile vs. brittle.*

Once again, this is not what is considered a normal 'story' but it fits within our definition because the speaker is intentionally relaying information as a series of experiences (i.e. twisting the chalk and observing failure planes). Choosing to relay the information as a story conveyed information about the participant such as her resourcefulness in using commonly available materials and her desire to integrate hands-on demonstrations into her classroom. The storyteller relied upon shared context when describing what she does in her classroom and the story additionally gave her credibility by indicating some level of teaching experience. All of these before mentioned aspects of the story are unique to Storytelling Performance.

As the initial stages of brainstorming concluded and groups moved onto designing their innovation, stories progressed to Conversational Interactions where the storyteller answered questions that pertained to their specific story, which is demonstrated in the excerpt below:

**Participant A:** *I have one, one set that weren't actually yard sticks but a guy that was there before me at [university name] had taken and glued like six planks, the yard stick size planks, together, and then took another six and nailed them right at the middle. And then I take them to class and push down the nailed one and it deflects and the ends go like that [motioning with hands]. So here is what happens with shear flow when you don't resist shear flow. And then ok try to bend the glued one, push on that end. That is always like, 'Ah wow. Ok. So the glue is doing something.' And we have a way to talk about what it is doing with shear flow and shear stress*

**Participant B:** *And how many nails do you think it would take to make it a composite [and to be equivalent to the glued one]?*

We see here how the storyteller told a story based upon a previous experience that allowed for the audience to participate by asking clarifying questions and opinions of the storyteller. This story was a natural extension to the group's discussion and easily allowed for others to participate, both key elements to a Conversational Interaction story. Additionally, the story was told to transmit a message, the message being how the use of manipulatives opened the door for the class to talk about the concepts demonstrated with the manipulative, another aspect of this type of story.

A similar interaction ensued in an adjacent group when discussing the use of a foam pool noodle within the classroom:

**Participant A:** *Really, instead of my bringing this out [referring to foam pool noodle with markings] at the end to show combined loads, this could come out for axial loads, it could come out for torsion, it could come out for bending moment. And so that same tool would address a whole lot of stuff.*

**Participant B:** *Do you use that for any of the other loadings?*

**Participant C:** *I do use it for axial but the problem is the buckling that wants to occur so that is hard. I haven't thought about using it for the bending mainly because I have that slit on it which is a little bit confounding.*

**Participant B:** *What is the purpose of having the slit?*

**Participant C:** *Umm...It is there because, the number one purpose is it is a fortuitous slit. It is there because I originally used a bunch of pipe insulation out of the attic of my house. And then I was like, 'Oh that is actually really good for showing that you have shear running longitudinally, not just around. Because they want to focus on that. So it shows that.*

Here we see Participant A telling a story about how she has used the foam pool noodle in the past and contemplating how she can use it in the future. Participant B then continues questioning the original storyteller, Participant C, on her use of the foam noodle to figure out how she uses it in her classroom and the purpose behind the slit. We see each additional story told by Participant C prompted an interaction with Participant B. Within this context it is likely that Participant B already knew that the demonstration would be useful in other loading cases, and therefore their question was more of a collaborative contribution to the ongoing story. Again, the participants are primarily sharing information but have chosen to do so in the form of stories. At this point in the workshop the stories have progressed from individual performances to more group-oriented discussions, allowing the group to emphasize shared meanings while clarifying misunderstandings.

Determining the final details of the innovation often spurred Social Process storytelling. These stories centered on negotiating the specific details of the innovation, which ultimately would impact how they would be utilized by instructors. In the following example, we see how the participants decided on the recommended group size:

**Participant A:** *So the first thing we will do is, we will pass out the pool noodles and umm, have students work in pairs or three's.*

**Participant B:** *I would actually go with a larger group than that, like four to five because I think four would be pretty optimal because if you get pairs or even three's you can sometimes have just not a dynamic where people share a lot but by the time you get to four you usually have..*

**Participant A:** *That is interesting because my perception is four, one person sits out and the other three work.*

**Participant C:** *It varies a lot per group. Two I think for this is too little and I think you need at least three.*

**Participant A:** *So want to say at least three to four?*

**Participant B:** *Yeah let the people decide what they want.*

**Participant A:** *Five seems it would be too big.*

The group ultimately found a consensus of three to four students per group based upon each person's insight into the situation and the sharing of past experiences. Though stories were not directly conveyed to the audience, the group relied upon a synthesis of their past experiences with group work to articulate what they thought was an optimal group size. The exchange quoted above is built upon all the previously shared stories so that, for example, when Participant A says "...my perception is four, one person sits out and the other three work," the group immediately

assumes that this perception is meaningful for them. Their assumption is scaffolded on all the shared meanings the group has developed through sharing other stories.

The above storytelling was constructive in the design process but some storytelling appeared to hinder progress. Upon further research, we came to understand the importance of using stories to motivate and inspire the innovation process which was seen in the following excerpt:

**Participant A:** *So a side story is that, we have a math center, in the Marine Sciences building that is a long narrow hallway and it has cross beams run across the top and so we picked up a grey whale skeleton. And you have seen it right? You've seen the whale? And so our Marine Sciences folks go, 'Can you help us hang the whale in the thing, in the hallway' and I said, 'What do you mean hang the whale in the hallway?' They say, 'Well we are going to hang the whale in the hallway, can you help us? Can you engineer for us?' And I said, 'You can't hang the whale in the hallway.' And they said, 'Sure we are going to hang it from those beams' [laughing] And I said, 'No.'*

**Participant B:** *How much does the whale weigh?*

**Participant A:** *2000 pounds, over 5 beams. I said, 'We can't do that.' And they are like, 'What do we need to do?' 'We need to calculate the beams.' And they were like, 'Can you do that?' And I said, 'No.' 'But why not? You're an engineer?' 'But I don't have a stamp. I don't have insurance.' And they were like, 'Details.' So we had to farm it out. We put U-channel on the fronts of all of them and bolted them down the central axis. But it's not coming down, they're [referring to the beams] not bending anyway.*

This story was told in the middle of discussing the design of the group's innovation. Though the participant recognized that it was a side story, it inspired a conversation about bending and how that is difficult for students to see. Additionally, you can see how this inspiration was later reflected in their final developed curricular materials.

Not only did the story assist in material development, it also helped to build a sense of community among the group. We see how the storyteller was frustrated with the Marine Sciences people in their assumption that anything can be hung from beams, as if they are decoration, but he was able to connect with the group by having a shared understanding of the importance of beams and the complex details that are involved in engineering practice.

The next example shows how a group member shared one of their classroom activities with the rest of the group while they were trying to figure out what is important to focus on during the innovation process.

*I will often take a foam piece in [to class] and push it in with my finger and ask [the students] what the stress is next to it? So how far away do you have to be before it is uniform pressure? It is the same concept as how far are you away from a hole before you are not worried about the hole? So maybe this is not something that is critically important. The more critical question is that there are effects and they are minimized.*

Telling this story about how the instructor presents a similar concept in his class inspired the rest of the group to focus on which of their ideas are essential for students to learn. This story aided in the shaping and creating of a ranking task question that would later be used to assess student understanding.

## Discussion and Conclusions

Storytelling is often thought of as a distraction from the work at hand. We have found, however, that many stories play important roles in productive collaborations. Initially, we see that Storytelling

Performance allowed participants to position themselves within the group and share their experience in a more socially welcoming way than being forthright and stating an extensive (and often boring) list of their credentials. The storyteller was the focus of these interactions with the rest of the group acting as an audience. Often these stories were lengthy and did not directly contribute to the development process but instead were related tangentially.

Commonly, groups would move onto a Conversation Interaction approach to storytelling. This approach began to directly influence the development process and involved interactions between the storyteller and audience. The audience often asked clarifying questions or for further details in regards to the story. Originating from participants' actual classroom experiences, these stories aided in the brainstorming process. When looking at the finished product from each group, we see remnants from these stories integrated into the developed innovation. For example, one of the activities the bending group settled on was having students load a wooden 2"x4" that spanned across a gap to imitate a loading scenario similar (but on a smaller scale and less risk) to the whale skeleton story.

Negotiating the final details of the developed materials, groups frequently relied upon Social Process stories to influence the group and lead them in a certain direction. Stories about their classroom experiences were used to inform the intricate details of development such as worksheet layout or recommended group size. Additionally, stories were used as a form of evidence or rhetorical devices to make a point or sway an argument towards their recommendation. These final and highly efficient modes of communication were predicated upon the mutual understanding and trust (at least in the limited context of curricular development) developed through the storytelling performances and conversation interactions.

Due to the nature of the workshop and the participants all having prior experience with Mechanics of Material content, the amount of shared context from the start was possibly greater than if researchers alone had collaborated on this project. Participants were able to exert less effort and time in finding common ground before starting to approach the problem. Spending less time on Storytelling Performance and more on Conversational Interactions appears to be beneficial to design and innovation as it allows for classroom experiences to be discussed and integrated into the final product. Using classroom experiences, by telling stories, to inform the design process could prove beneficial in more closely aligning innovations to their use in classrooms.

Though it can be difficult to discern what is considered a productive story, facilitators can use stories as a means to determine how the group is progressing. For example, a group that does not progress beyond Storytelling Performance could be experiencing underlying difference in group members' goals and motivations. Storytelling Performance should be supported initially by allowing enough time and flexibility within the schedule for participants to share their backgrounds in an organic manner. Though still present throughout the groups' interactions, Storytelling Performance should not be the most commonly told type of story as the group progresses. Facilitators could encourage progression and the transition to Conversation Interactions by encouraging more equal time amongst all speakers, or by assigning groups that account for individual personalities and diverse backgrounds. Assigning heterogeneous groups that can still establish sufficient shared contexts would lead to an increased level of creativity and a wider range of ideas, both of which are important to the innovation process.

Future work will look at how stories told during material development can influence the potential adoption of said innovations.

## References

Abrahamson, C. E. (1998). Storytelling as a pedagogical tool in higher education. *Education*, 118(3), 440.

- Adams, R., Allendoerfer, C., Smith, T. R., Socha, D., Williams, D., & Yasuhara, K. (2007). *Storytelling in engineering education*. Paper presented at the American Society for Engineering Education Annual Conference. Honolulu, Hawaii.
- Alterio, M., & McDrury, J. (2003). *Learning through storytelling in higher education: Using reflection and experience to improve learning*: Routledge.
- Andrews, D. H., Hull, T. D., & Donahue, J. A. (2009). Storytelling as an Instructional Method: Definitions and Research Questions. *Interdisciplinary Journal of Problem-Based Learning*, 3(2).
- Beckman, S. L., & Barry, M. (2009). Design and Innovation through Storytelling. *International Journal of Innovation Science*, 1(4), 151-160.
- Cheryl, A., Ken, Y., Robin, A., Dawn, W., Tori Rhoulac, S., & David, S. Storytelling In Engineering Education.
- Dempster, J. A., Benfield, G., & Francis, R. (2012). An academic development model for fostering innovation and sharing in curriculum design. *Innovations in Education & Teaching International*, 49(2), 135-147.
- Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social problems*, 436-445.
- Henderson, C., & Dancy, M. H. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics-Physics Education Research*, 3(2), 14.
- Kıncal, R. Y., Beypinmar, D., & Topçu, F. (2013). Teachers' Perceptions And Experience On Professional Learning. *Annual International Conference on Infocomm Technologies in Competitive Strategies*, 169-173.
- Langellier, K. M. (1989). Personal narratives: Perspectives on theory and research. *Text and Performance Quarterly*, 9(4), 243-276.
- Lordly, D. (2007). Once upon a time.... Storytelling to Enhance Teaching and Learning. *Canadian Journal of Dietetic Practice and Research*, 68(1), 30-35.
- Lowenthal, P. R. (2008). Online faculty development and storytelling: An unlikely solution to improving teacher quality. *Journal of Online Learning and Teaching*, 4(3), 349-365.
- McDrury, J., & Alterio, M. (2002). *Learning through storytelling: Using reflection and experience in higher education contexts*: Dunmore Press Limited.
- Meirink, J. A., Meijer, P. C., & Verloop, N. (2007). A closer look at teachers' individual learning in collaborative settings. *Teachers & Teaching*, 13(2), 145-164.
- Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. *Executive Office of the President*.
- Rogers, E. (2008). M.(2003) *Diffusion of innovations*: New York: Free Press.
- Shank, M. J. (2006). Teacher storytelling: A means for creating and learning within a collaborative space. 22(6), 711-721.

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