Journal of Engineering Education Transformations ,
Volume 38, No. 4 , April 2025 , ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2024/v38i4/25098

The Saga of the Dance School: Digital Storytelling in a Fluid Mechanics Classroom

Ashish Karn [1], Mrityunjai Verma[2], Raman Kumar Singh [3], Gaurav
[1]Department of Mechanical Engineering, School of Engineering, UPES, Energy Acres, Bidholi, Dehradun, Uttarakhand, India 248007
[2]Department of Mechanical Engineering, University of Washington, Seattle, Washington, USA 98195
[3]Indian Institute of Technology Delhi, Hauz Khas, New Delhi, 110016
[1]akarn@ddn.upes.ac.in
[2]mrityunjaiverma5301@gmail.com
[3]smz198290@iitd.ac.in
[4]gmittal@ddn.upes.ac.in

Abstract—Education in engineering has invited a wide variety of pedagogical approaches ranging from classroom demonstrations, computational simulations, Excel-VBA tools, project-based learning, flipped classroom to even Japanese Anime. However, there are hardly any reports on the integration of digital storytelling in engineering education. The current paper examines the efficacy of the digital storytelling methodology in engineering education. A digital story for a Fluid Mechanics classroom on the specific concept of Reynolds number, a dimensionless parameter often utilized in Fluid Mechanics, is thoughtfully conceived, developed, implemented for second-year engineering students, and evaluated based on student feedback. The statistical data taken from the anonymous student surveys clearly attest to the overwhelming benefits of digital storytelling approach as a very useful pedagogical tool in engineering education. The paper reports how a seemingly mundane story, crafted using ingenious storyline and vivid imagery, can successfully implant vital and crucial Fluid Mechanics concepts in the minds of students, which are difficult to comprehend theoretically. Further, it has been found that bringing down an abstract concept to the mundane realm empowers learners to visualize fluid motion as a tangible reality, and deduce rational insights into the behaviour of fluid flow. When utilized under the guided sphere of digital storytelling, such a pedagogical approach clearly stands out on many fronts as a very efficacious way of facilitating learning and making classroom environment fun, interesting, and full of suspense: elements that evoke the attention span of students.

Keywords—Dance school; digital storytelling; engineering education; fluid mechanics; Reynolds number

Ashish Karn
Department of Mechanical Engineering, School of Engineering, UPES, Energy Acres, Bidholi, Dehradun, Uttarakhand, India
akarn@ddn.upes.ac.in

1. Introduction

Stories have pervaded collective human consciousness since eternity (B. R. Robin, 2008; Van Gils, 2005). They often times carry an inherent purpose – sometimes sheer entertainment, but many a times, that of instruction and learning as well. Stories can be used not only for the purpose of presenting the subject matter, but also as a means of instilling a sense of devotion to the alignment of the topic's motivation.

The old and expansive epics of the world, such as Mahabharata, Ramayana, Iliad and Odyssey etc.

contain many stories and employ storytelling as a didactic pedagogical tool (Van Gils, 2005). One could very easily trace the genesis of different storytelling paradigms in them – such as stories nested within stories, allegories and so on. In fact, one of the earliest and remarkable usage of storytelling as a pedagogical tool can be seen in Panchatantra, a collection of stories with the animal kingdom as the principal characters (Edgerton & others, 1924). Its author, Vishnu Sharman, used anthropomorphised animal characters with human behavioural patterns to instil education and learning in the minds of readers with great efficacy.

Setting aside the tradition of tales throughout the human history, storytelling can also be an effective tool for formal education as well as social awareness & change regarding a wide range of real-life topics. Furthermore, the advancement of multimedia technology has endowed us with an opportunity to combine the art of storytelling with computer-based tools (Alismail, 2015; Anderson, 2011; Choo et al., 2020). It has altered how individuals experience and consume tales, as well as the tools accessible to the teachers for storytelling. Such digital storytelling (DST) involves researching, creating, analysing, and integrating visual images with text and voice in an effective way which enhances and accelerates comprehension (B. Robin & Pierson, 2005).

Fundamentally, in the matter of comprehension and information retention, human brain is not like a computer storage device. Although it might simplify education if we could simply dump all necessary raw facts directly into a person's brain, but that is still the subject of science fiction only. Throughout the ages, people have taught their children and others using stories. Stories convey not only information, experience and wisdom, but more importantly, they excite sympathetic reactions within the listeners that enable them to comprehend, retain and also apply the learned concepts to other situations. Our brains are simply better equipped to understand and retain narrative and information in context than to retain bare facts. In engineering and science, wherein technical concepts and procedures are often difficult to understand, the issue of comprehension and long-term concept retention requires consideration and appropriate pedagogical practices; DST is certainly an effective pedagogy to this end.

The usage of DST over a range of heart-churning social contexts, for instance as a forum for medical professionals and patients to share stories and moral support, avocational storytelling programs to provide opportunity to victims of violence to connect with their creativity and tell stories in their own words, memorial stories depicting legacies & heritage etc. have been amply emphasized (McLellan, 2007). Several studies have documented the efficacy of DST in fostering creative thinking, attitudes toward the lesson, student motivation, confidence and satisfaction levels, enriching the learning environment, increasing academic success, supporting learning in a cooperative manner, making the lessons fun and enjoyable, increasing participation, and communication skills (Clarke & Adam, 2012; Hava, 2021; Hung et al., 2012; Lowenthal & Dunlap, 2010; Nair & Yunus, 2021; B. R. Robin, 2008; Sadik, 2008; Yang et al., 2022; Yoon, 2013)

However, the majority of studies in DST have been in the humanities and social-science areas. Wu and Chen (Wu & Chen, 2020) presented a systematic review of 57 studies on educational DST with usage across primary, secondary, and higher education levels and noted that the pedagogy has usually been explored in the humanities and social science contexts with predominance of language and literacy domains. Nonetheless, it can potentially be an effective strategy in science education as well (Bilen et al., 2019; Sadik, 2008).

Several studies have presented the role of DST in science education as well as in training of science teachers. These studies have, however, focused on K-10 grades. A project-based DST approach was applied to 5th grade students and compared with conventional project-based learning (Hung et al., 2012). In this work, project-based learning with DST was shown to enhance students' science learning motivation, problem-solving competence, and learning achievement. Students of 6th and 8th grade science class and their parents attributed a high level of satisfaction in learning to DST activities (Güven & Sülün, 2012; Saritepeci, 2021). Kahraman (Kahraman, 2013) discussed the effect of use of DST on the topic of 'force and motion' on the success and motivation of 9th grade students. The effect of DST on "Our Earth, the Moon and our Source of Life the Sun" unit of the 6th grade science curriculum on students' academic success, attitudes, and motivations toward learning science was analysed by Bilen et al. (Bilen et al., 2019). It was concluded that DST positively affected the academic success and attitude of the

students in the experiment group when compared with the students in the control group. Olitsky et al. (Olitsky et al., 2020) considered a DST based redesign of a college course, that entailed a partnership between a college neuroscience classroom and a high school. In this study, the college students used digital storytelling and social networking to communicate 'authentic science' to high school students.

Techno-pedagogical development of science teachers has also been evaluated through facilitating them to create science-based DST activities for pre-school & primary school students (Gürsoy, 2021; Sancar-Tokmak et al., 2014; Yilmaz & Sığirtmaç, 2023). Such studies have emphasized that DS development provides a strong foundation for the development of 21st-century skills, and teacher education programs should be supported by DST activities and instructions (Orhan Göksün & Gürsoy, 2022).

It is evident that DST has been used as a pedagogical tool for science at K-10 level to some degree, whereas its use in higher science and engineering has remained untapped. In scientific topics, precision is often paramount, and such precision is often best represented in terms of abstract equations, plots, and tables of data. A narrative or storytelling approach may, at first, appear out of place for a science or engineering classroom. However, in coherence with the reported K-10 science studies, we hypothesize that DST can be a powerful tool, especially in the field of engineering education, where complex subjects can be bifurcated into simple elements to inculcate better understanding. DST can then be used for concretizing abstract engineering concepts, which can be taught within a plot with the accompaniment of a storyline.

In pursuance of the aforesaid notion, the objective of this work was to thoughtfully develop a digital story for a Fluid Mechanics classroom while being mindful of the essential elements of storytelling, implement it and evaluate its educational efficacy. In the vast field of science and engineering education, fluid sciences still remain a complex area of study for both students and instructors. Studies suggest that a large number of students studying fluid mechanics find it difficult to visualize concepts due to the complexities of procedures. Memorizing and retaining concepts like turbulence tend to be difficult when explained theoretically or even with two- or three-dimensional diagrams. Hence, in order to make fluids education a bit easier to understand, DST can be incorporated. Relating technical terms to items that are seen and dealt with every day, can make concept retaining better and hence, fluid mechanics easier to understand. With this objective in mind, the developed digital story, named The Saga of a Dance School, is implemented for the second-year students of Mechanical Engineering in their Fluid Mechanics class.

In the following sections, the narrative is presented, followed by an analysis of its essential elements, the results of student feedback and conclusion. Based on the literature survey, we believe that this study reports a unique attempt to incorporate DST in engineering education.

2. The Narrative: The Saga Of A Dance School

The digital story must contain certain essential elements that enable and facilitate realization of various aspects of the objective of effective learning. The following elements were considered as imperative to the purpose.

- Creation of a take home message
- Setting up the stage following a dramatic beginning
- In-depth character description
- Rise and fall of emotions
- Usage of vivid descriptions to create mental imagery
- Conflict and struggle, depicting drama
- Suspense and reflection on the story
- Voice intonations to enhance story depth
- Usage of graphics and background music

The story was developed keeping the aforesaid elements in the foreground. An analysis and impact of these elements with reference to the developed story is discussed in the next section. The narrative goes as follows.

Let me tell you a story, an amazing story to make you think. This story is about a “Dance School”, a

school whose Principal, Mr. Scrooge believed in disciplining his students to the utmost. He saw that his students mixed with each other, frittered around and lost all their constructive energy. He did not like it. He did not like his students to poke into others' business. A disciplinarian of the highest order – he hated to see his students quarrelling and breaking things apart, no matter what. After all, for Mr. Scrooge - a penny saved was a penny earned!

But what irritated Mr. Scrooge most was the school dance teacher, who was incorrigible in her approach toward teaching dance. To the weird dance teacher, dance did not mean just the classroom session. The dance teacher believed that students should be extrovert, frivolous and a bit mischievous. She provoked her students to mingle, mix around, go frolicking, tease others and have fun. No seriousness whatsoever! Absolutely No discipline of any sort.

The dance hall in the school was located at the centre of the school and had multiple gates that opened to the many corridors in all directions, leading to a museum constructed concentrically around it. These corridors were of different sizes. Some were narrow, whereas some were wider and spacious. But all the corridors were well maintained and beautiful posters and artwork adorned their walls and glasses. Unfortunately for Mr. Scrooge, the sincere disciples of the dance teacher did their numbers as they walked past these corridors. They danced and frolicked, broke the glasses and tore the posters and made paper planes out of them - making the museum a complete mess. The principal was furious over the increased maintenance expenses.

Finally, he thought of a great idea. He appointed the class-teacher to watch over the students and make them walk in a line, as they came out of the dance class in the corridors. The students however were so playful and unruly that the class teacher struggled miserably to stop the disorder and to bring things under. After struggling for a while, she petitioned to the Principal narrating her woes. She made three points in her petition:

- Although I can make the lighter kids walk in a line, I am not strong enough to stop the disorder of the heavier folks.
- If the students come running too fast, their mingling and the chaotic motion is unmanageable.
- The narrow corridors are fine and is under control, but the kids make a ruckus in the wide corridors.

The frustrated Principal appointed another stronger class teacher to look over. The stronger class teacher succeeded to some degree. But soon enough, he gave up, unable to come up to the great expectations of the Principal to make everyone walk in a line.

The Principal learnt a lesson – No matter what you do, the kids like mingling with each other and there is nothing you can do to absolutely stop it. But wait, who said it's bad? The mixing between the kids can be a great thing, at times.

The storyline depicting the flow of the story is shown in Fig. 1. It describes successive phases of the digital story and gives a brief overview of consecutive events. It is important to observe how colours, font, illustrations and stop motion videography and animation have been utilized to develop a foundation and deliver specific emotions and messages. The described components of the story have been put in to use based on meticulous understanding of the relationships and connections of the concept of flows with an attempt to amalgamate it with an interactive and relatable experience for students.

Fig.1 : The storyboard gives an idea of the flow of the story and also depicts a clear picture of the usage of different components to build up the narration.

3. Analysis of The Digital Story

The saga of a dance school contains a rich amalgamation of various elements mentioned in the previous section, making it a good example of an effective story telling attempt (cf. Fig. 2). The following section relates the elements of a story to the tale of the dance school and explains its correlation to fluid mechanics.

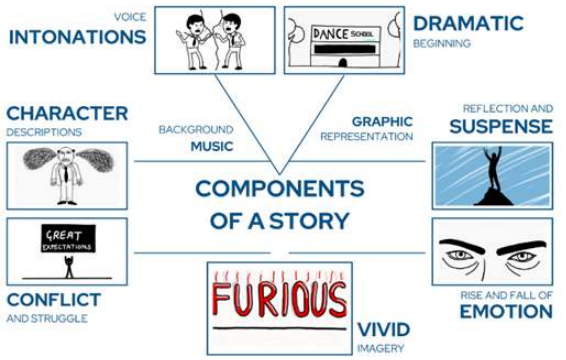

Fig. 2 : The elements of the story

A. Creation of a take home message

Relating the story to the concept of fluid flow, it is very important for the students to be able to take away a significant level of understanding of fluid flow and the nature of flows under different conditions. An effective way to achieve the same is to create an interesting array of questions in the students' minds. The following list of questions was added to the story to inculcate a level of eagerness in the student's mind that could force him/her to think about what the story was all about and what feature of the story related to which aspect of fluid flow.

Questions)

- Who are the kids?
- Who is the class teacher?
- Who is the dance teacher?
- Who is the meticulous Mr. scrooge?

The significance of a take home message is hence, one of the most important elements of a story. The questions help students with the basics of flow visualization with respect to the nature of flow. The story very efficiently relates the mischievousness of the students to turbulent flows. the following conclusive statements can be made on the technical front:

a) The kids are the fluid particles who always tend to move and mingle freely. When these fluid particles move in a line in a disciplined fashion, the flow is called laminar whereas it is turbulent when the fluid particles move in an unmanageable manner.

b) The class teacher is a symbolic representation of viscous force that tends to dominate over inertial forces in order to ensure laminar flow.

c) The dance teacher is the inertial force that dominates the viscous force and as a result, the flow becomes turbulent (students become mischievous).

B. Setting up the stage following a dramatic beginning

The primary aim of storytelling is to attract the attention and interest towards the concept of the story. The first impression, being very crucial, must be highly impactful. This decides whether or not the story will be able to achieve the deliverables of conceptual understanding. Especially in the fluid sciences classroom, it is very important to create an interactive atmosphere in the very beginning to create a spark of interest in the students that can help them visualize complex concepts with great ease. Taking the dance school story as an example, the voice intonation of the speaker itself sets up a stage that creates a sphere of eagerness. It is followed by the introduction of the dance school and how students are uncontrollable due to being frivolous. The introduction of a "problem statement" can make the viewer intrigued to know what more does the story has to offer.

The statement- "Let me tell you an interesting story", creates a stage for levelling up the expectations and eagerness of the viewer. The description of how Mr. Scrooge, being extremely meticulous, always wanted the students of his school to be disciplined, creates weight to the set stage that can subsequently be used to pile up a series of events. The dramatic beginning acts as a supportive medium to story narration and helps develop the narration of the plot.

C. In- depth description of the characters

Defining the characters is an important aspect of transporting the readers to the world of tales, bringing

the events to life, and creating captivating characters. Without description, the viewers will be unable to visualise or comprehend the tale. A high-quality in-depth description is essential.

The story describes Mr. Scrooge as an absolutely meticulous person who always wants his students to follow rules. Mr. Scrooge's character gives depth to the story and one can actually relate to what he wants and what are the consequences as a result of his actions. Another character description that makes the plot strong is that of the dance teacher. The dance teacher's approach towards teaching dance makes the students more mischievous. The story intents on creating a relation between different components of the concept of fluid flows and the described characters. The dance teacher has been described to be highly influential amongst her students and her influence leads them to be more indisciplined and mischievous. As a result of the same, the students are seen destroying the school property. This shows that the dance teacher's actions make students behave in a particular way. This is the base that has been utilized to relate the teacher's character to a flow governing agent. Considering the technical aspects of the concept, inertial forces are the dominant ones in creating turbulence. Hence, the dance teacher can be compared to the inertial forces.

The triangle of dispute completes with the introduction of the students who are the reason for all the damage. The influence of the dance teacher makes the students more playful and hence troublesome. The description of the students' character gives a clear vision about them being an important factor of the consequences.

There are two major statements that can be used to understand the relativity of the students to the concept of flows.

"Unfortunately for Mr. Scrooge, the sincere disciples of the dance teacher did their numbers as they walked past these corridors. They danced and frolicked, broke the glasses and tore the posters and made paper planes out of them - making the museum a complete mess."

The above statement gives an idea on how students are playful and destroy the corridors as they run past it. Joining the dots to the previously made statements, the influence of the dance teacher makes students the way they are. Hence, it can be concluded that the dance teacher causes some kind of instability to make students mischievous.

"Finally, he thought of a great idea. He appointed the class-teacher to watch over the students and make them walk in a line, as they came out of the dance class in the corridors. The students however were so playful and unruly that the class teacher struggled miserably to stop the disorder and to bring things under."

The class teacher tries to get students under control but fails due to the dominance of the influence of the dance teacher. Hence, the influence of the dance teacher dominates over that of the class teacher.

D. Rise and fall of emotions

Have you ever been dragged into the time and location of what was going on, felt the emotions of the individuals present, and resonated with the 'why' and 'how' of the purpose and cause for those human beings? We can put ourselves in those shoes via storytelling. We may relate to their history and sentiments. We can consider what we would do in that case. The emotions we experience link us to the tale. Depending on how our emotions react to the activities of others, such sensations may inspire us to act or behave differently (more nobly, more resourcefully, more effectively).

Great tales may instil empathy in students. The neurochemical oxytocin is at the root of this. Paul J. Zak shows in his book "How Stories Change the Brain" that throughout experiments, character-driven stories with emotional depth consistently increased oxytocin synthesis (Zak, 2013), i.e. one's brain

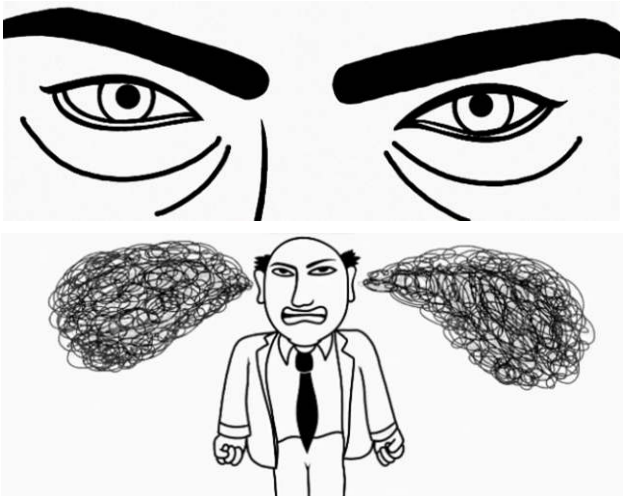

Fig. 3 : The emotions of Mr. Scrooge

responds with empathy, sympathy, compassion, caring, and connection as one is emotionally moved by the narrative.

The story comprises of various instances where voice intonations and facial expressions have been used to create ups and downs in the emotion of the story (cf. Fig. 3). It is the way a story is narrated that one gets to be inside a character's skin. The story then makes one a part of the story where one can imagine and feel different perspectives that characters have. Due to the emotional content, the students may imagine themselves in the same circumstances, they may achieve a better grasp and memory of the essential point.

E. Usage of vivid descriptions to create mental imagery

Sensory imaging is the creation of mental images via the use of descriptive words. Sensory imagery is a sort of imagery in literary terms; the distinction being that the sensory imagery works by activating five senses of the reader. Any written account of a sensory event might be labelled sensory imagery. The majority of literature incorporates some sort of imagery. One reason fiction authors use a lot of precise description is to let the reader make their own judgements and conclusions based on visual cues. However, authors do not necessarily have to describe how things seem to build mental images. Describing how something tastes, smells, sounds, or feels, rather than merely how it looks, brings a passage or scene to life. The use of imagery and sensory imagery provides the reader with as much information as possible and aids in the creation of a more vivid mental picture of what is happening.

"The dance hall in the school was located at the centre of the school and had multiple gates that opened

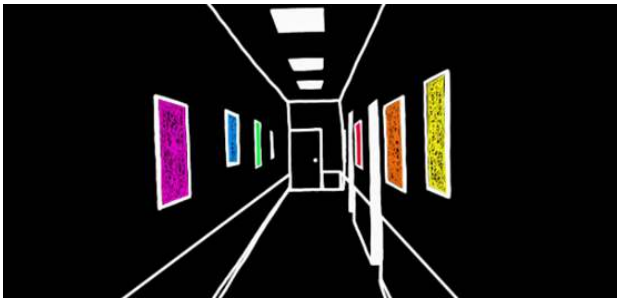

Fig. 4 : The description of scene. Notice the graphical and illustrative representation of the corridors making the viewer a part of the scene

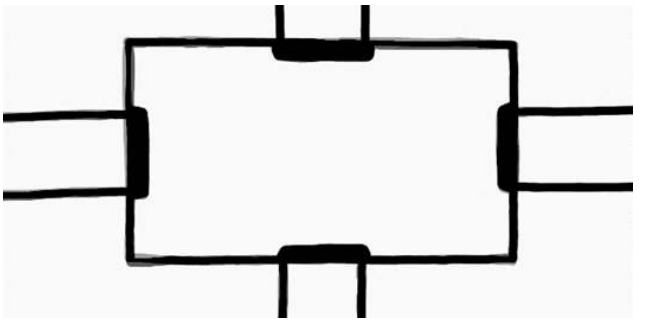

Fig. 5 : The different levels of description of the same scene. The narration first describes the layout of the dance school and then magnifies the description to explain the detailed picture of a particular corridor (Fig. 4)

to the many corridors in all directions, leading to a museum constructed concentrically around it. These corridors were of different sizes. Some were narrow, whereas some were wider and spacious. But all the corridors were well maintained and beautiful posters and artwork adorned their walls and glasses"

Mental imagery lets the viewer create interesting scene and action in the mind. It is critical to set the setting for a story. Giving readers a clear understanding of when and where situations happen helps to ground action and conversation (Fig. 5).

F. Conflict and struggle in a story

A story's conflict is a battle between competing forces. Individuals must react to oppose these forces, and a conflict arises. There is no tale if there is nothing to overcome. In a tale, conflict produces and propels the storyline forward. External conflict refers to the challenges that a character experiences in the outside world. Internal conflict refers to a character's psychological or emotional challenges. Moral or philosophical issues arise when a character's worldview or belief system clashes with the outside world. It is important to note that seeing conflict solely in terms of external and interior dimensions is overly simple. A proper definition of conflict in a tale also includes its relevance to philosophical or moral conflict.

The triangle of conflict between the principal being furious over the children creating a mess leading to high maintenance expenses, the dance teacher's negligent approach and the class teacher's failed attempts to manage the students creates an engaging conflict and jumbles the viewer's brain until the climax of the story is introduced and the conflict is

resolved. Defining the conflict in a story also introduces the viewer to the problem statements that are used to clear the concepts for which the story is narrated. This is realized through the presentation of three points in class teacher's petition to the principal.

G. Suspense and reflection on the story

Suspense is another element that keeps the learners engaged in the story. In "The saga of a dance school," the suspense is created through the various challenges faced by the characters and their journey towards success. By inculcating a sense of curiosity within the student's brain, suspense can be used as a great tool to keep the viewer hooked on the story, right from the very beginning. The development of suspense in a setup like that can be done by careful sequencing of information and successive drama in the story. This can be followed by strategically discovering essential takeaways, for example, concepts, problem solving skills, etc., such that the viewer is encouraged to actively think and analyse possible outcomes for a given scenario.

Reflection, in addition to suspense, is critical in strengthening students' comprehension and developing a more meaningful learning experience. Educators urge students to pause, analyse, and integrate the offered content with their past knowledge and experiences by including reflection points throughout the digital tale. Reflection enables students to analyse and create connections between the knowledge they have received, allowing them to build mental representations and frameworks of thought. Through reflection, students are able to actively engage in metacognitive processes, evaluating their own understanding and identifying any gaps or misconceptions.

Finally, the usage of graphics, background music and voice intonations to enhance story depth can be noted in the animated story at the following link:

https://www.youtube.com/watch?v=yiw-26Xj_ZQ

4. Demystification Of The Story: A Fluid Mechanics Perspective

The fluid mechanics perspective to the aforesaid story can be understood keeping in mind the fundamental nature of fluid particles and their motion in a viscous flow. In such a scenario, the 'kids' can be likened to the fluid particles who always tend to move and mingle freely, and in doing so, lose their energy to the viscous dissipation. When these fluid particles move in an orderly fashion, the flow is called laminar whereas when the fluid particles move in an unmanageable and chaotic fashion – it is aptly called turbulent. Evidently, there must be then an agent that drives the layered 'laminar' flow into a turbulent nature, aka the dance teacher. Hence, the dance teacher is (Ms.) Instability, one who provokes these fluid particles to get turbulent. On the other hand, the persistent agent that tries to ensure a layered flow can be understood as viscosity. Hence, the class teacher is (Ms.) Viscosity, one who tries to dissipate the naughtiness of the fluid particles due to their inherent inertia and disciplines them.

Clearly, there is a “tussle” between the dance teacher and the class teacher as students move about in the corridors. In the terms of the fluid motion, this can be visualized as the competing action of instability and viscosity as fluid particles move in conduits. The flow in the corridors can be likened to the flow in a pipeline (Fig. 5) and whether or not the fluid particles can be disciplined depends upon the relative strengths of the class teacher and the dance teacher. Again, in terms of the fluid motion, the relative magnitudes of inertial forces and viscous forces, or the Reynolds number determines the transition to turbulence for fluid motion in a conduit. Reynolds number (Re) is given as:

For fluid motion in a conduit of size D, any increase in fluid density, ρ or fluid velocity, U or a reduction in the fluid viscosity μ results in net predominance of inertial forces over viscous forces and thus a larger Re. Typically, for flows in a conduit, flow is observed to be laminar at low Re ($Re < 2100$) , in a transitional regime at intermediate Re ($2100 < Re < 10,000$) and turbulent at high Re ($Re > 10,000$). This variability is qualitatively narrated in the story by the mention of the lighter kids (alluding to low density fluids), low running speed of kids (low flow velocity) as well as narrow corridors (less D). In addition, the impact of viscosity upon governing the transition to turbulence is highlighted through the instance of a ‘weaker’ and ‘stronger’ class teacher who tries to discipline the students. Clearly, when the viscous force dominates, the flow stays laminar and when the viscosity is not large enough, the instabilities in the flow make it turbulent.

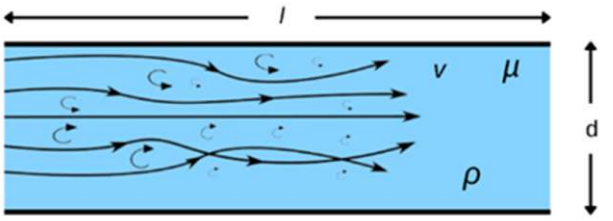

Fig. 6:Turbulent flow visualisation in a closed pipe

There are many other instructional messages camouflaged in the story – which are crucial points for instruction and revelation to the students. Two such cases can be considered here: the depiction of Mr. Scrooge – who is keen on saving money. In a way, he depicts an industrialist in real life who wishes to keep the turbulence to a minimum in the pipeline flow, to save his expenses on the pumping cost. This is a fundamentally important point of learning for the students studying pipe flows – the students must begin to appreciate the dependence of pumping costs upon the flow parameter. Next, the concluding line of the story may be taken. It states that the mixing between fluid particles is not always bad – although alluding to the beneficial impact of the company of kids on each other, in fact, it refers to the many desirable applications in industry where turbulence is induced in the flow to cause such mixing.

5. Results And Discussion

The efficacy of the developed digital story was assessed by implementing it in a second year Fluid Mechanics subject for Mechanical Engineering students. The class consisted of 32 students. The following section presents a discussion of the quantitative and qualitative analyses of student surveys.

Quantitative feedback

Anonymous feedback from students were obtained for fifteen hypotheses which spanned various physical, cognitive, teaching-methodology, participation, creativity and overall recommendation aspects. These aspects are categorized in Table 1.

Students were required to assess each hypothesis on a scale of 1 to 5 with a rating of '1' being 'strongly disagree', '5' as 'strongly agree' and '3' as 'neutral'. The response obtained from students are summarized in Fig. 6. In order to test hypotheses and ascertain their statistical significance, z-test for mean was used. The mean response values for hypotheses along with p-

Table : 1
Hypotheses relevant to various aspects of quantitative feedback

	Hypothesis
	Physical aspects
1.	**Effectiveness over oration:** The digital story is more effective in comparison to oral story telling
2.	**Voice and Music:** The voice of instructor and the background music has enriched this video and made it more enjoyable
3.	**Proper pace:** The pace of the story is perfect for the students to absorb and understand the content and the message behind it
	Cognitive aspects
4.	**Enhancement of comprehension:** This way of teaching helps students to get rid of reservations towards abstract concepts and makes them more comprehensible
5.	**Deep Insights:** The digital story provides relevant insights and deep understanding about fluid flows that cannot be necessarily gained by books
6.	**Enables Analysis:** The story enables students to analyze and visualize fluid flows in other scenarios as well
7.	**Engaging:** The story is entertaining and engaging and makes it easier and helpful to learn complex concepts
8.	**Conveyance of wisdom:** The story does not just communicate information but conveys experience and wisdom and does excite a sympathetic / emotional response.
9.	**Lasting impact & Retention:** The story has a lasting impact on the student's mind.
	Teaching methodology
10.	**Integration of technology:** Demonstrates the integration of technology in the classroom and opens students to its use.
11.	**Flipped approach:** The story provides for an ideal way of flipped classroom learning.
12.	Vividness in teaching: The digital story makes teaching vivid and brings a new flavor to the teaching style.
	Participation
13.	**Enhances Interaction:** The digital story enhances and increases social interaction both inside and outside the classroom
	Creativity
14.	**Creativity/ originality:** The content of this story is original and creative
	Overall
15.	**Overall Recommendation:** The digital story is highly recommended for other abstract concepts in other engineering courses as well

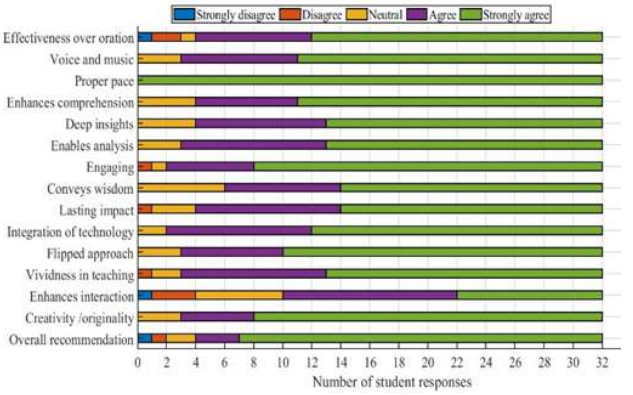

Fig. 7 : Student response to hypotheses

values are reported in Table 2. Since all p-values are miniscule, all hypotheses are accepted in this study. The tests are conducted based on the same segregation of aspects as mentioned in Table I.

It is evident from Table II that DST developed and implemented in this study was received exceptionally well by the students. The overall response values in almost all aspects, namely audio-visual, cognitive, teaching methodology and creativity, averaged around 4.5. A slightly lower average of 3.84 was realized for 'enhances interaction'. It is thus concluded from this study that DST in engineering classroom can significantly improve the comprehension of abstract concepts, can make a lasting impression, and bring vividness to classroom. Even though the concept of different types of flows is a complex one to visualize and understand, the digital story effectively delivers deep insights on the working of various procedures involved in fluid flows. It is crucial for a story to be substantially relevant to the original concept and the story of dance saga effectively delivers the same. Another important aspect to look out for is the lasting impact that the student would have after experiencing the narration of the story. Making learning lesser complex by inculcating digital storytelling helps the student retain concepts for a larger time frame. The story would be a driving force for concept retention even after a long span of time.

Table 2 :
Mean And P- Value of Hypothesis

No.	Hypothesis	Mean Value	P-Value
1	Effectiveness over oration	4.38	4×10^{-14}
2	Voice and Music	4.56	4×10^{-40}
3	Proper pace	5	0
4	Enhancement of comprehension	4.53	8×10^{-34}
5	Deep Insights	4.47	3×10^{-31}
6	Enables Analysis	4.5	8×10^{-37}
7	Engaging	4.66	4×10^{-41}
8	Conveyance of wisdom	4.38	5×10^{-23}
9	Lasting impact & Retention	4.41	1×10^{-23}
10	Integration of technology	4.56	1×10^{-46}
11	Flipped approach	4.59	4×10^{-42}
12	Vividness in teaching	4.47	5×10^{-28}
13	Enhances Interaction	3.84	5×10^{-06}
14	Creativity/ originality	4.66	5×10^{-47}
15	Overall Recommendation	4.56	1×10^{-19}

2) Qualitative feedback

Apart from the qualitative assessment, students also commented on the use of DST in engineering classroom. An analysis of student comments was carried out to gain a more nuanced perspective on the impact of the digital story on individuals. Representative comments along with the concept highlighted are the following.

"Voice modulation makes the story extremely dramatic. This made the story so relatable. I will never forget the story." – Voice modulation (component of storytelling) and retention

"Teachers have the option of using already made digital stories as an educational tool to engage students and provide knowledge when introducing new ideas." - Digital Storytelling as an effective teaching and learning tool

"Great! Digital storytelling makes any concept easier to understand and it becomes unforgettable." - Concept retention

"Digital storytelling, in my opinion, is both incredibly entertaining and useful for comprehending fluid mechanics." – Entertaining and comprehension

"Even though I find Fluid Mechanics to be one of the most difficult subjects, I will never forget the

concept of laminar and turbulent flows." - Making difficult concept like fluid mechanics easy to understand

"What I feel on a personal level it is a way better than the books and it make the concepts really easy to understand and relate." - comprehension

"It impacted my way of studying and understanding complicated concepts." – Development of positive attitude

"This was a very creative video clearly depicting behaviour of molecules without using the word molecules. Brilliant method of teaching and making us understand the concepts." - Relating technical terms to items that are seen and dealt with every day

Impact analysis of the digital storytelling approach on the learning outcomes

The impact analysis of the digital storytelling technique on the learning outcomes of a Fluid Mechanics course can be typically gauged by evaluating its footprint specifically on the course outcomes as well as generically on the program outcomes of undergraduate Mechanical engineering program. The following analysis delves into how digital storytelling influences both course-specific and broader program outcomes, highlighting its potential to significantly improve engineering education.

Of the four course outcomes of the Fluid Mechanics course, the proposed DST technique significantly impacts the two outcomes below: 1) Understanding Fluid Properties and Governing Equations: The digital storytelling technique enhances comprehension by presenting fluid mechanics concepts through engaging narratives. Characters and their interactions serve as analogies for fluid particles and their behaviour, making abstract concepts more concrete and memorable; and, 2) Mathematical Analysis of Fluid Flow: Storytelling simplifies mathematical analysis by providing clear mental models. The disciplined movement of students in narrow corridors (laminar flow) and chaotic behaviour in wider corridors (turbulent flow) and its dependence upon the width of the conduit, the role of density and viscosity of the fluid as well as flow parameters such as velocity facilitates a better grasp of the mathematical factor Reynolds number and why increasing it is related to increasing turbulence.

In addition, a correlation with the program outcomes of the undergraduate Mechanical engineering program can also be made, albeit its contribution of such a technique on the program outcomes can only be gauged when such a strategy is used for multiple courses in a recurring manner. The digital storytelling technique integrates the application of engineering knowledge, problem analysis, and solution design by embedding these processes within an engaging narrative. This method encourages students to apply mathematical, scientific, and engineering principles to solve complex problems by relating them to the storyline. It aids in the identification and formulation of engineering issues, fostering critical thinking and deep analysis. By following the narrative, students observe the design and development of solutions, learning to consider public health, safety, and environmental factors. The storytelling approach mirrors the investigation process in engineering, helping students understand research methods and data analysis. It familiarizes students with modern educational tools, enhancing their technical proficiency and adaptability. Contextual elements in the story address societal, health, safety, legal, and cultural issues, helping students appreciate the broader implications of engineering practice. Ethical dilemmas and professional responsibilities are reflected in the characters' scenarios, instilling ethical principles. The collaborative nature of the story's characters models effective individual and team work, demonstrating the importance of functioning in diverse teams. Communication skills are enhanced as students learn to convey complex engineering activities effectively. Finally, digital storytelling fosters a love for learning, encouraging students to recognize the importance of lifelong learning and staying updated with technological changes. Thus, an intervention such as this in teaching fluid mechanics significantly enhances learning outcomes by making complex concepts more relatable and easier to understand. It fosters critical thinking, problem-solving, and the application of engineering principles in real-world contexts.

Conclusion

This study introduces a novel application of digital storytelling (DST) in higher education, specifically within the fluid mechanics classroom, marking a significant departure from its predominant use in humanities and early science education. The findings clearly demonstrate the profound impact of DST on enhancing student comprehension of complex

engineering concepts, such as fluid flow dynamics, which are often abstract and difficult to visualize. By seamlessly integrating technical content into an engaging narrative, DST not only facilitates a deeper understanding but also cultivates long-term retention of critical concepts.

The results from student feedback, both quantitative and qualitative, substantiate the efficacy of this pedagogical tool. Students reported heightened engagement, enhanced problem-solving abilities, and a marked improvement in their ability to analyze fluid mechanics scenarios. The vivid, metaphorical narrative of the "Saga of a Dance School" enabled students to personify fluid particles and forces, fostering a concrete grasp of otherwise intangible scientific principles like turbulence and viscosity.

This work underscores the untapped potential of DST in the engineering domain, a field traditionally reliant on technical rigor and abstract equations. Through storytelling, abstract scientific notions can be contextualized, making them accessible and memorable. We envision that future applications of DST in engineering education will not only enrich students' academic experiences but will also foster a more intuitive and creative approach to problem-solving in scientific domains.

As educators, it is incumbent upon us to explore and refine innovative teaching methodologies that bridge the gap between theoretical knowledge and practical understanding. Digital storytelling has proven itself to be a potent vehicle for this purpose. Thus, we conclude that the incorporation of DST in engineering curricula has the capacity to revolutionize the educational landscape by making learning more relatable, impactful, and enduring.

Declarations

Data Availability Statement: The data used in this study, including student feedback, are currently owned by the authors are not publicly accessible as of the publication of this paper.

The hypothesis and standards for quantitative and qualitative student feedbacks have been created by the authors and are not available publicly.

However, to promote transparency and enable further research, the authors are willing to provide access to the data upon reasonable request. Interested parties may contact the corresponding author for inquiries and to discuss the terms of data sharing.

Declaration of consent: The conducted study (student feedback) is anonymous and does not involve the personal/ medical details of any individual. Informed consent was obtained from all individual participants included in the study.

References

Alismail, H. A. (2015). Integrate digital storytelling in education. Journal of Education and Practice, 6(9), 126–129.

Anderson, D. V. (2011). Storytelling—the missing art in engineering presentations. IEEE Signal Processing Magazine, 28(2), 105.

Bilen, K., Ho\cstut, M., & Büyükcengiz, M. (2019). The effect of digital storytelling method in science education on academic achievement, attitudes, and motivations of secondary school students. Pedagogical Research, 4(3), 1–12.

Choo, Y. B., Abdullah, T., & Nawi, A. M. (2020). Digital storytelling vs. Oral storytelling: An analysis of the art of telling stories now and then. Universal Journal of Educational Research, 8(5A), 46–50.

Clarke, R., & Adam, A. (2012). Digital storytelling in Australia: Academic perspectives and reflections. Arts and Humanities in Higher Education, 11(1–2), 157–176.

Edgerton, F., & others. (1924). The Panchatantra reconstructed: an attempt to establish the lost original Sanskrit text of the most famous of Indian story-collections on the basis of the principal extant versions (Vol. 2). American oriental society.

Gürsoy, G. (2021). Digital Storytelling: Developing 21st Century Skills in Science Education. European Journal of Educational Research, 10(1), 97–113.

Güven, G., & Sülün, Y. (2012). The effects of computer-enhanced teaching on academic achievement in 8th grade science and

technology course and students' attitudes towards the course. Journal of Turkish Science Education, 9(1).

Hava, K. (2021). Exploring the role of digital storytelling in student motivation and satisfaction in EFL education. Computer Assisted Language Learning, 34(7), 958–978.

Hung, C.-M., Hwang, G.-J., & Huang, I. (2012). A project-based digital storytelling approach for improving students' learning motivation, problem-solving competence and learning achievement. Journal of Educational Technology \& Society, 15(4), 368–379.

Kahraman, Ö. (2013). Dijital hikâyecilik metoduyla hazırlanan öğretim materyallerinin öğrenme döngüsü giriş aşamasında kullanılmasının fizik dersi başarısı ve motivasyonu düzeyine etkisi.

Lowenthal, P. R., & Dunlap, J. C. (2010). From pixel on a screen to real person in your students' lives: Establishing social presence using digital storytelling. The Internet and Higher Education, 13(1–2), 70–72.

McLellan, H. (2007). Digital storytelling in higher education. Journal of Computing in Higher Education, 19, 65–79.

Nair, V., & Yunus, M. M. (2021). A systematic review of digital storytelling in improving speaking skills. Sustainability, 13(17), 9829.

Olitsky, S., Becker, E. A., Jayo, I., Vinogradov, P., & Montcalmo, J. (2020). Constructing "authentic" science: Results from a university/high school collaboration integrating digital storytelling and social networking. Research in Science Education, 50, 505–528.

Orhan Göksün, D., & Gürsoy, G. (2022). Digital Storytelling in Science Teacher Education: Evaluation of Digital Stories. Science Education International, 33(2), 251–263.

Robin, B., & Pierson, M. (2005). A multilevel approach to using digital storytelling in the classroom. Society for Information Technology & Teacher Education International Conference, 708–716.

Robin, B. R. (2008). Digital storytelling: A powerful technology tool for the 21st century classroom. Theory into Practice, 47(3), 220–228.

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. Educational Technology Research and Development, 56, 487–506.

Sancar-Tokmak, H., Surmeli, H., & Ozgelen, S. (2014). Preservice Science Teachers' Perceptions of Their TPACK Development after Creating Digital Stories. International Journal of Environmental and Science Education, 9(3), 247–264.

Saritepeci, M. (2021). Students' and parents' opinions on the use of digital storytelling in science education. Technology, Knowledge and Learning, 26(1), 193–213.

Van Gils, F. (2005). Potential applications of digital storytelling in education. 3rd Twente Student Conference on IT, 7(7).

Wu, J., & Chen, D.-T. V. (2020). A systematic review of educational digital storytelling. Computers \& Education, 147, 103786.

Yang, Y.-T. C., Chen, Y.-C., & Hung, H.-T. (2022). Digital storytelling as an interdisciplinary project to improve students' English speaking and creative thinking. Computer Assisted Language Learning, 35(4), 840–862.

Yilmaz, M. M., & Sığirtmaç, A. (2023). A material for education process and the Teacher: the use of digital storytelling in preschool science education. Research in Science & Technological Education, 41(1), 61–88.

Yoon, T. (2013). Are you digitized? Ways to provide motivation for ELLs using digital storytelling. International Journal of Research Studies in Educational Technology, 2(1), 1–10.

Zak, P. (2013). How stories change the brain. Greater Good: The Science of a Meaningful Life, 17, 1–4.