Presented at 'Creative-Science 2013', Kings College London, 29th November 2013
(as part of the 3rd Immersive Education Summit)

# Storyweavers

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**Abstract.** This Creative Science paper reviews critical thinking and suggests that rather than a purely mental construct, good thinking is embodied and situational. The concept of embodied expertise is presented, followed by a story in a not so distant future when nanobots implanted in people's bodies will allow us to modify brain and body signals, creating virtual worlds that will blend with or entirely replace reality. This paper argues that the challenges that we currently face require educators not only to teach skills but also to help people find their path in life. Beyond delivering information, it is speculated that teachers will be asked to translate knowledge, experience and expertise into fully immersive stories.

**Keywords.** Science fiction, critical thinking, embodied cognition, embodied expertise, immersive worlds, storytelling

## Introduction

Our society faces difficult challenges, with a growing number of individuals suffering from depression, neurosis, alcoholism, and drug addiction. Suicide rates at global level have increased by 60% in the last 45 years, according to Suicide.org. We are seeing a considerable number of teenagers who are victims of bullying and harassment and reach the unfortunate conclusion that death is better than life. We are also witnessing increased violence and rage in young people that have lost hope in the future.

The educational system spends considerable time delivering information but in many cases, as young students, we are not taught how to face deeper issues. In school we learn mathematics, chemistry and physics, but we receive little help regarding how to go about life, which is what most of us focus on throughout the rest of our existence.

After decades of promoting rote learning and unquestioned premises, we have arrived to a point where we may have to conclude that our model is not working. As Facione mentions, "the eighties witnessed a growing accord that the heart of education lies exactly where traditional advocates of a liberal education always said it was – in the processes of inquiry, learning and thinking rather that in the accumulation of disjoined skills and senescent information" [1]. The eighties are long gone, but education has kept the desire to help people think better.

How feasible is it to teach critical thinking? Imagine for a moment that you are a prisoner in a cave where the rays of the sun can never reach you. You, however, lead an unquestioned existence, since you have never been aware that you are a prisoner. You know there are others like you, because you can hear their voices and you can talk to them. All of you spend your time pondering the shapes that are projected on the wall by a fire you cannot see, shadows to which you give different names, like

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"mountain" and "tree". That constitutes "reality" for you and your fellow prisoners, even though it's just a reflection. Suddenly one day you manage to escape from the cave following a rough and steep path. Reaching the outside world you are able to see for the first time the real mountains and trees, the lakes and oceans. Thrilled with your new understanding, you pity those you left behind in the cave, for what they consider reality is not more than a shadow of the world. So you decide to go back and 'enlighten' those who are still in the cave, but what you say sounds incoherent to them, and finally they conclude you must be mad, a menace to their well-preserved status-quo, and kill you.

You probably recognized in this previous tale a short unorthodox summary of Plato's Myth of the Cave. In my opinion, it summarizes how difficult it is to change thinking patterns in individuals. We resist change and anyone who tries to change us. We normally go about our business unaware of our beliefs, content with our realities, until a crisis forces us to check our assumptions. Can we teach how to think better before we reach a crisis? Could the solution to teaching critical thinking skills be the words of Cicero? "If you wish to persuade me, you must think my thoughts, feel my feelings, and speak my words." This Creative Science paper explores this possibility.

## 1. Thinking Critically

What is critical thinking? Since critical thinking is commonly confused with problem-solving and decision-making, the American Psychological Association decided to create a panel of experts, their objective to systematically arrive to a definition [1]. The consensus was that critical thinking is a "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. As such, critical thinking is a liberating force in education and a powerful resource in one's personal and civic life." The definition goes on to describe the critical thinker, cognitive skills and sub-skills involved, and affective dispositions. Even though this definition is certainly valid and encompasses the many variations of critical thinking, I would like to focus on more practical versions, which are essential for everyday living.

In educational gerontology and adult education, critical thinking is related to challenging long-held beliefs and judging how efficient they are in the context of a new reality. In this situation, critical thinking (CT) can be considered a tool to find the meaning of one's existence [2].

In a ground-breaking work in the field of adult education, Brookfield proposed that critical thinking involves two processes: identifying assumptions, and exploring and imagining alternatives [3]. The purpose of identifying one's assumptions is to uncover strategies that were acquired in childhood without much evaluation, and challenging their validity and applicability to one's current situation. Usually, though not always, a difficult situation or crisis triggers this process. The second part of CT takes care of producing new alternative paths or ways of thinking that will agree more with reality.

In the same line, Mezirow's perspective transformation deals with the process of reflecting on perspectives culturally acquired, and how they impact us and our relationships [4]. Mezirow agrees with Brookfield in identifying 'life dilemmas' as the triggering events of transformation, and also in that this process cannot be carried out

in an individual vacuum but requires a social dimension that will allow discussion and validation of new paradigms.

The emancipatory nature of CT is shared by Paul, who divided the construct into macro-logical skills (of emancipatory nature) and micro-skills (technical) [5]. As a guiding force, it is seen by Ennis as "reasonable reflective thinking focused on deciding what to believe or do" [6]. CT as a means to free oneself from unchallenged paradigms is the process that underlies the search for meaning in a specific situation –and at a larger scale of one's existence– in order to efficiently deal with it.

In this emancipatory definition of critical thinking the underlying assumption is that thinking is a purely mental process, disconnected from our bodies. However, there has been a relatively recent shift in the way we view cognition, from considering it a purely internal process to being situated, distributed and embodied.

## 2. Critical Embodiment

Cognitive, perceptual, and motor operations cannot be seen as separate as it is frequently the case. Memory-based and perceptual-motor strategies act together to influence the way the individual interacts with the environment. It can be said that cognition encompasses not only formal operations 'in-the-head' but also the situation the individual is in, the physical properties of the environment he/she is acting on and the body used to act upon the environment. The environmental context provides opportunities for action (affordances) which our bodies are designed to detect and act upon, creating a cycle of action and feedback [7]. Learning is defined then as the "education of intention and attention" [8].

Embodied cognition is not a clear-cut construct. Simple embodiment sees the body as a constraint on the internal processes and representations [9]. The flow of information from the environment through the body and to the mind is what Clark considers cognition. A more radical approach is that of Chemero which directly stems from Gibson's ecological psychology and abandons mental representations entirely, what Chemero calls 'cognitive science without mental gymnastics' [10].

If we adopt an embodied perspective, then rather than using logic and other purely rational tools to teach critical thinking, we need to make the individual aware of the possibilities for action afforded by the current situation, mindful of how the body is reacting and how it is influencing, and how in turn it is influenced by thoughts and mental images. I suggest that critical thinking goes beyond mental models and is more in line with what Suwa calls 'embodied expertise' [11]. I would summarize embodied expertise as the optimal balance between mental processes, sensory and perceptual information, body skills and the surrounding environment.

Embodied expertise would be applicable to all levels of what we define as critical thinking, from the skills required to play an instrument or dance, all the way up to the process of giving direction and meaning to our lives. Immersive technologies are starting to offer us the possibility of 'living' knowledge rather than understanding it at a purely conceptual level.

## 3. Storyweavers

### *3.1. Zara*

Zara was not looking at the vast ocean in front of her. Her eyes were focusing on empty space while in her mind she revisited the path she had followed to reach the top floor of the Observatorium, the massive structure on the artificial island of Miura. The memory of sneaking through forbidden corridors and doors made her fair skin redden slightly. Her hands were still shaking and her heart was beating fast. She bit her lower lip and raising her hands to the top of her head, she undid her ponytail and run her fingers through her hair. Her silky black hair framed her delicate features and contrasted with her big turquoise eyes. Gently she massaged the stiff neck and shoulders.

She sat on the wide fence bordering the building's roof. Was there any way to fix this mess? She thought about this old song from years ago. Immediately the nanobots inside her body lit up and began sending neural impulses that resulted in a high-definition three-dimensional hologram of a song retrieved from her memory right in front of her eyes. The sound enveloped her entire body.

"Whenever something is too unpleasant, too shameful for us to entertain, we reject it. We erase it from our memories. But the imprint is always there", said the face in front of her.

Her thoughts switched to the days and hours that had led to that moment. The holographic image in front of her eyes receded in space and was replaced by images of her body and her most inner thoughts and desires paraded all over the global stream for everyone to see. Her profile holograms were all vandalized with obscene drawings and hurtful insults. Some went as far as encouraging her to 'just die'. However, she realized that being physically naked in front of everybody was not as painful as being ridiculed for her adolescent dreams. Because she fell in love, she was accused of being easy. Because she dared to explore, she was accused of being an ugly whore. Everything she had thought of becoming was trampled on viciously. Even her music.

Music moved her and took her to places she could not reach any other way. Shyness turned into wizardry when she played the violin. Before she had to carry the instrument wherever she wanted to play it, but all that changed when she met Iain. She did not know where he came from but she was fascinated by him. It was her birthday and she received this strange card from him: "Open me and what you love will always be close to your heart". She thought he was referring to himself, except for the use of 'what'. She opened the file and felt a strange tingling sensation. She recognized that her system had installed something that modified her nanobots. After a few seconds the centuries-old Alard violin, one of Stradivarius' finest creations, materialized in front of her eyes. She had smiled thinking it was a common hologram but then he heard Iain's voice saying: "Come on, play it!"

First generation nanobots, like the ones she used to carry, were only allowed to modify an individual's perception system up to a certain point, for fear that their capacity to influence sensory and neural signals could be misused. Humans could interact with holograms and they could feel almost like the real thing but playing a holographic instrument had remained a challenge because it required modifying brain and body signals in a way that was strictly forbidden. It was not just about touching the instrument. It was about the precise texture, its response, the acoustics, even how it felt in one's hands and how it influenced one's body. Iain had told her about second

generation nanobots that could emulate these experiences and more, but he had been very secretive about it.

She felt silly but grasped the bow with her left hand and with her right hand rotated the instrument to place it on her collarbone, finally resting her jaw on the chin rest. She propelled the bow and music flowed as if she were playing the real thing. She felt a strange sensation, as if someone was driving her execution, but she was soon carried away by the sounds of the instruments and her own mind.

After that day she started feeling music in a completely new way. Her body moved as if she were a different person, in a manner that she could not understand but felt just right. After that day she could not say no to Iain.

"We can be connected now, you and me. We can share our thoughts and desires. We can be one, never mind where we are!" Back on the roof of the Observatorium she remembered she had indeed shared everything, much more than she should have.

She thought of the violin and the nanobots created the illusion of the playable instrument in front of her once again. She stood on the edge of the fence, two kilometers away from the ground, and started playing. The sound of the violin followed the ethereal voice of the song she was listening to.

"Can't fight it all away, Can't hope it all away, Can't scream it all away, It just won't fade away."

Tears fell down her face, her eyes closed. The nanobots, still reacting to her thoughts, surrounded her with holograms of her parents listening to her play, and her sister that used to tease her calling her 'creepy ghost' because of her pale complexion. Completely immersed in the music she felt weightless. She played for a long time not noticing the cold wind against her skin. Suddenly she stopped, breathed deeply and opened her eyes.

"God, please don't hate me."

*3.2. Ailsa*

"I hope I won't get into trouble", thought Ailsa. The web of messages danced in a three-dimensional mesh in front of her eyes, reconfiguring themselves according to the way she wanted to search. She found the one she was looking for and isolated it with her mind. After struggling with herself for a while, she unwrapped the content: the MeridianMod in all its glory, and a modified dance environment to go with it –courtesy of Zara's mystery boyfriend– were ready for her.

She held the files and opened her hands. She felt the code modifying her nanobots and once the process was over, she checked her body to see if she felt any different. Nothing. She opened the dance mod and chose a song. A hologram appeared in front of her, ready to demonstrate the routine. Ailsa started moving her body slowly following the music. She knew this routine well. Suddenly, she felt a gentle twist of her leg moving it in a slightly different manner from the way she normally did.

"You've got to be kidding me…"

Great dancing did not come just from the brain but from the understanding of the music piece and the interpretation the dancer created about what that music meant emotionally. It naturally depended on the motion of different body parts and where those movements where taking place. The environment, other dancers, the energy of the music and audience, delivered cues that the expert was able to decode but the novice overlooked. Of great importance was the dancer's awareness of his/her own body through the proprioceptive system. Apart from augmenting all these elements and

delivering real-time information to the prospective dancer, as first generation nanobots did, second generation nanobots went further by modifying the information between the brain, the body and the holographic and real environments around the individual.

So with first-generation nanobots, a person could see a holographic teacher, imitate its form and superimpose his or her own hologram to see where the differences were in real time, striving to match the correct technique. Color codes, plan-like lines and highlighted symbols quickly indicated the areas where everything was working well and those that needed improvement.

In contrast, second-generation nanobots, which were created by Professor Ethan Suk to enhance learning, added emotion and embodiment. They modified sensory and perceptual information in order to reach the perfect level of training. Thinking about moving a hand in a specific way was not the same as actually moving it that way. The dancer could attempt to do the exact motion of the model, but lack of training or physiological constraints could result in the wrong movement. Or the technique would be perfect but performed without emotion or expression.

Here is where the new nanobots would kick in. Coded within the example offered by the experienced dancer were the levels of emotion translated into brain chemicals, and the exact muscle and joint motions that were necessary to achieve that specific level of proficiency. Nanobots would induce the same emotional states by modifying the levels of brain chemicals and would send signals to muscles and joints to replicate the exact same motion.

The trainee would at the beginning be almost like a puppet, but as the dancer's body became closer to the target, nanobots reduced their influence. Dancers would no longer go through long hours of training without having a clue about what it really felt to be a great dancer.

Second generation nanobots were at research stage and faced a steep path to being approved because of the potential control nanobots could have over physical and emotional states. What Ailsa was experiencing was a modified version created by hackers.

Ailsa quickly chose a difficult song, one that she called her 'nemesis'. Whenever she danced that routine, the teacher's hologram and her own would engage in what tended to look more like a Sumo wrestling match than a coordinated dance. Watching the reviews made her sometimes wonder if she should have been better off doing something else.

She was ready. A sudden energy flow went through her body. She felt the nanobots gently sending sensory information to her muscles and joints. She felt a bit like invisible hands twisted her limbs gently correcting her moves and getting them closer to the expert's. Her skin felt almost like touched by the music, her face reacting to every single nuance in the musical piece. She thought of visualizing herself and she appeared as a hologram right next to the trainer. But this time it was different, she moved gracefully and for the first time she really felt that song and understood what it meant to move her body to that tune. She continued dancing with herself, her body sensually flowing as carried by invisible guides. Nanobots released the right chemical soup to reach a state of pure emotional flow with the music.

Suddenly, one of the nanobots' state changed and started to release an increased dose of epinephrine. Ailsa started feeling a sense of exhilaration and her heart started pounding. A few seconds later, the nanobot induced the release of phenylethylamine, which in turn triggered dopamine. She felt attractive and sexual. She smiled at her holographic self, flirting a bit like she would with a real partner. It was then that the

nanobot started to broadcast an encrypted holographic signal of her sensual dancing. She was enjoying herself very much. And so was Iain.

### *3.3. Chief Inspector Kinlan*

Chief Inspector Cerys Kinlan sat in front of a long table. Rather than each individual being physically present in the room, each chair was filled by a hologram, an immediate transmission of the actual person located somewhere else on the planet. The table and chairs, except for hers, were of course the product of her own nanobots recreating the necessary space for the meeting.

The Web 4.0 was now standard across the entire globe. People could access information and get it directly delivered to their brains. Humans did not just visualize information. They were immersed in streams of data. Advanced artificial intelligence delivered the right content at the right moment. Anyone could access any information resource and learn anything they wanted. Education had become widespread even in the poorest areas of the world. Nevertheless, depression had become the number one global disease followed closely by other mental diseases. Stress and anxiety dominated a society of overpopulated cities with hundreds of millions of people and scarce resources.

"Where is she?", asked Cerys.

"We don't know, ma'am. The last satellite transmission of her position indicated that she was moving towards the outskirts of the city but we lost her after a while. She has activated her firewall and we have not been able to trace her."

The hologram in front of them showed a 3d map of the city with an orange path glowing through the transparent-blue buildings and stopping in the Nova district.

"We are the police department and we cannot track a teenager, is that what I am hearing?"

"Ma'am, we have 300 million people in this city, almost 100 artificial islands surround it with roughly the same population. Also, she is not a regular teenager. She is highly intelligent and she has upgraded her nanobots to second generation. We are only experimenting with them so far. She has applied the MeridianMod patch to her system."

Second generation nanobots were not available to the public but hackers had been quick to create a patch, the MeridianMod 1.0, its name based on the autonomous sensory meridian response, which was defined on the global stream as a "perceptual phenomenon characterized as a distinct, pleasurable tingling sensation in the head, scalp, back, or peripheral regions of the body in response to visual, auditory, olfactory, and/or cognitive stimuli." The patch was a modification of Professor Ethan Suk's work.

The mod allowed direct sensory and perceptual information in the brain and body to be modified. It made possible to mix the virtual world with the real one in an almost indistinguishable manner. It also allowed full access to the individual's system.

"And where is he?"

"He is under custody, ma'am".

"Good, we are not as ineffective as certain people claim. And what do we know about him?"

"He is a sort of regular kid, relatively social. He moved out of his parent's place a couple of months ago, because according to him they were just too stupid to understand him."

Cerys nodded and a new hologram materialized in the centre of the room. She carefully observed the athletic man staring directly into her eyes. She did not expect him to have glowing glyphs tattooed on his scalp and his neck. Cerys' younger sister was considering getting them but she thought they looked weird on a man. She noticed Iain kept one eyebrow raised and his lips slightly pursed as if he was the one analyzing her.

"I want you to hack into her system and stop her from doing something stupid. Now."

"She gave me access to all the information I posted. Now she is making a big deal out of it."

"She trusted you and you took advantage of her."

"She was the one complaining about not being able to play her stupid violin everywhere."

"You accessed private thoughts and sensory information that did not belong to you, and made them public. You broke the law and you could be held responsible if anything happens to her".

"She should have read the fine print", answered Iain with a grin.

Cerys wished at that moment she also had second generation nanobots so she could slap him and make him feel at least some degree of pain.

"I will make sure you don't enjoy one more day of freedom if you don't help us."

"What freedom?", he yelled back. "You mean the freedom to roam the streets? The freedom to see people starve to death? I don't care about your stupid freedom. People die every day. She will be just one more."

Chief Inspector Kinlan stayed quiet for a moment and then, using the same tone of voice she had used all along, said: "You will help me find my sister or I will make you suffer beyond anything your mind considers possible in this world".

*3.4. Ethan Suk*

From the messy white hair, unshaved face and wrinkled clothes one could conclude that Ethan Suk had been hiding in some dark corner of the planet, alone with his computer, for the past two centuries. An emeritus professor at one of the leading global universities, he had created the original code on which the MeridianMod was based.

"As you well know, Chief Inspector Kinlan, I created this code with the idea of going one step further. Just sharing information is not enough for humanity. For far too long we have lived in our heads. Our bodies need to be incorporated into the equation. Our mental, sensory and perceptual systems are important parts of what makes us human, and they are involved in how we apprehend knowledge, in how we interact with the world. My idea was simply to take human learning to the next level. I have conceived a way where essentially you can perceive what I perceive and interpret it in the way I do, generate your own concepts or share mine, and follow my body response or chose your own. So far we have augmented all physical places on Earth. I can go to Stonehenge and see with my own eyes what happened there centuries ago, explore and even play a role in that society. But this is still purely a mental exercise. I have no idea about how they perceived their world, or why they reacted the way they did, or how their bodies behaved in that world in response to that specific environment."

"That's all very good, but your code allowed this hacker to steal images, thoughts and sensations from my sister and post them all over the stream. I need to find her before she does something foolish. And you will help me".

Professor Suk took a deep breath. “I would not call Iain a hacker. Old school hackers have ethics. For them, the goal is to create art and beauty using a computer. We may disagree with their concept of art and beauty, but they do believe computers can change life for the better, even though they reject authority.”

“Iain seems to be the destructive type”, he continued. “Highly intelligent, he gets easily bored with what regular people term ‘education’.”

“Spare me the psychological profiling. Can you get into his system?”

“He has a solid firewall but I am confident I can see what he is up to”. Professor Suk proceeded to work with his holographic computer. He did not need to type code as his thoughts were transcribed directly into the compiling console. Eye-motion determined the steps he wished to follow. After a couple of minutes he stopped.

“Ok, I am in. But you will not like what he is doing.”

With a swift gesture, he shared his holographic display with Cerys. Ailsa was dancing almost naked in front of them. “I have severed the communication, she will be ok now. I think I have an idea. Maybe now is time to test my theories, if you allow me to do so. We might need permission to run this procedure.”

“Forget permissions, I will deal with that later”, Cerys said. “Just get my sister back.”

*3.5. Iain*

“Hello, Iain. I am Ethan Suk.” Professor Suk’s hologram appeared in front of Iain’s field of vision.

“How did you bypass my firewall?”

“Let’s say I have a more refined version of your mod. Like a 1.5 sort of thing”.

“Your code was junk. I just made it better”, replied Iain.

“I am a messy coder, you are right, but I learned from my mistakes. But you know I am not here to talk code. I severed your communication link with Ailsa because it was active. You have cut all communication with Zara, why?”

“I could not stand her whining. So people have seen her naked. Big deal!”

”I think you went further than that. You stole her thoughts and desires, a whole bunch of private information that was not yours to share.” Suk paused for a moment and then added in a calm voice: “Iain, a girl is about to die if you don’t stop her.”

Iain looked at Suk for a moment and then asked: “What kind of upgrades have you made?”. Suk looked puzzled for a moment but answered the question. “My nanobots are able to control lower versions of nanobots at all levels. I can present myself at will, like I just did. I can create illusions for other people. I can write their realities if so I wish.”

“Is it even legal?”

“Coming from you, Iain, that is a very strange question to ask.”

A second later Suk knew his strategy had succeeded. By taking advantage of a vulnerability planted in the code, Iain was hacking Suk’s system and had downloaded the upgrade.

“As I said, your code is still junk. Now let’s see what this can do”, said Iain with a proud face.

Professor Suk’s holographic projection appeared to be affected by static. “You see, Iain, it is time for me to try a little trick of mine. I designed this program to help people understand anything at a very profound level, not just in their heads. I lied when I told you that I could create any reality I wanted. In fact, I needed a tiny piece of code in

your system, the one that you have just kindly installed. I have written a new reality for you."

Iain was no longer in his cell with Suk. He was in a black and white world, one step beyond redemption. He saw the crumbling roofs and towers of gothic cathedrals, ruins of magnificent buildings hidden by a dense forest of dead trees. He tried to scream and cursed Suk but the only sound was that of death. He felt the cold wind burning his skin. Following the dry bed of a river covered with ice, he run for what seemed like hours, falling again and again. Out of breath, dark gray blood covering his face, he reached a cliff and fell to his knees. He faced distant colorless memories, broken promises, and unlived dreams, creating a phantasmagoria of emotions he could barely handle. All of a sudden everything stopped and what he saw in front of him was the view from the Observaturium. He then heard his own voice: "Zara, stop!"

## 4. Conclusion

While the literary merit of the previous somewhat dark story is highly questionable, I wanted to present a perhaps naïve view of what technology might one day enable us to do with respect to what we currently call teaching and learning.

If we conceive experience as embodied, then better thinking will really mean better perceiving, feeling and acting, within the specific reality we face. In general, the tools we use in educational institutions, at least beyond a certain age, teach the mind only. We sit for hours and listen, when perhaps we should be moving, talking and acting.

As educators we are in charge of teaching different kinds of skills but I believe that as our world changes, we will also be more in charge of helping people live. Whenever someone says the word 'education', images of formality, boredom and stillness fill people's minds. Nevertheless, in essence what we do in life is to learn and most of us don't find that particularly dull.

Immersive technology can bring a level of embodiment to learning beyond anything we have seen so far. Naturally there will be risks, and we will have to debate how far we can go. In this new environment, we will be asked to move beyond the delivery of information and create realities that will help us learn and safely make mistakes. We will no longer be able to compartmentalize knowledge. Instead we will be required to string together skills, domain-specific facts, competencies, attitudes, motivations, emotions and all the components that allow us to apprehend reality, be it playing an instrument, building a rocket or understanding the reason why we are here. Through technology, educators will create immersive stories where people will experience and appropriate our collective wisdom.

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