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## From Streams to streaming: A critique of the influence of STEM on students' imagination for a sustainable future

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### Abstract

This article provides a literature-based critical review of STEM (Science, Technology, Engineering and Mathematics) and STEM education. STEM is located in and contributes to a neoliberal view of economics and is narrowly focused on technological solutions to global problems. As such, it is unable to provide the kind of education students at all levels need for them to understand, imagine and prepare themselves for a sustainable future. The article calls for a reframing of science away from the technological focus of STEM, i.e. techno-science, towards a science of reconnection with nature and an opening of students' imagination, and considers some of the elements of university leadership that are needed to enable this.

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## Introduction

Without the soaring birds, the great forests, the sounds and coloration of the insects, the free-flowing streams, the flowering fields, the sight of the clouds by day and the stars at night, we become impoverished in all that makes us human (Thomas Berry, 1999, p. 200).

Over the past decade, STEM (Science, Mathematics, Engineering and Technology) has been promoted as critical for Australia's prosperity into the future, and its spinoff, STEM education is promoted as the vehicle for increasing student literacy in these fields at all levels of education. A major concern to us is that the avid promotion of STEM education has resulted, intentionally or otherwise, in edging out of students' access to Education for Sustainability, which focused on the environment and sustainability (Smith & Watson, 2019). In this article we develop our thinking further to argue that the strong promotion of STEM education is contributing to the further distancing of students from the natural world, and hence is complicit in the narrowing of the imagination outside the confines of a narrow technologically-focused future. Accordingly, there are implications for leadership within Higher Education.

## Situating STEM

STEM is firmly located within a techno-optimist future (Allen, 2006; McKeown, 2018) that requires technology to be central to the continued innovative potential of humanity in adapting to changing situations with new ideas, and translating those new ideas into practice. For many in positions of power, the dominant view is that technology alone is the engine that will continue to drive progress and finally overcome our myriad problems (Dean, 2016).

The Australian government and its Chief Scientists are particularly enthusiastic promoters of a STEM-mediated technological future. The former Chief Scientist, Ian Chubb, in arguing for a STEM strategy, noted that its key objective is "to utilise fully Australia's capacity in STEM to secure social, cultural and economic prosperity for all Australians while positioning Australia to advantage in a changing world" (Office of the Chief Scientist [OCS], 2013, p. 8). Chubb further argued that investing in mathematics, engineering and science is the key to productivity growth and higher living standards in order to position the Australian economy as a whole for the future (OCS, 2013).

The Australian Government's recent National Innovation and Science Agenda (2017), links directly into this position, asserting that, "[e]xtraordinary technological change is transforming how we live, work, communicate and pursue good ideas. We need to embrace new ideas in innovation and science, and harness new sources of growth to deliver the next age of economic prosperity in Australia" (para. 1). This has become the nation's "innovation obsession", as Carter (2017) describes it (p. 9).

The promotion of STEM as the vehicle for promoting neoliberal values is also clear from the many utterances of

its current Chief Scientist, Alan Finkel. Finkel argues that because we exist in a competitive international environment, in order to compete effectively, business and science need each other (Lee & Hannam, 2015). As the former Prime Minister Malcolm Turnbull, who appointed Dr. Finkel put it: "Dr Finkel is renowned for his outstanding research, industrial and entrepreneurial achievements in Australia and overseas ... His will be a vital role in shaping Australia's economic future and leading our national conversation on science, innovation and commercialisation across the research, industry and education sectors and with the wider community" (Prime Minister of Australia, 2015, paras. 5-9).

Translating these messages into professional learning for teachers, the Commonwealth Scientific and Industrial Research Organisation (CSIRO)'s program STEM Professionals in Schools (2019), claims that,

[b]y connecting industry with schools, teachers and students are exposed to the relevance of STEM in everyday life. STEM Professionals in Schools increases teachers' confidence and encourages students to consider STEM as a future career path, which will be essential to meet Australia's future economic growth and productivity.

## The rise of STEM

We argue that the largely uncritical positioning of STEM as the means to meeting our economic needs, not to mention dubious arguments about it liberating us from drudgery through the creation of large amounts of knowledge-based work, is essentially flawed (Smith & Watson, 2018). The avid promotion of STEM aligns with a shift towards a more fluid iteration of progress in the era of modernity — the turbocharged, digitally mediated successor of industrial culture known as 'hypermodernity' (Smith & Watson, 2019; Smith, Fraser, & Corbett, 2017). This version of progress is increasingly centred around and dependent on the power of science and technology, with STEM framed as the vehicle to supercharge it (Smith & Watson, 2016).

Hypermodernity is the latest incarnation in the evolution of deeply-held beliefs about human exceptionalism that can be traced back to the Western worldview arising from the European Enlightenment. Humanity is positioned as the pinnacle of creation, liberated by technology to manipulate and consume nature at will for its own needs and gratification. Through the harnessing of fossil fuels during the Industrial Revolution, this position has come to represent all that is good and worthy in human progress and success (Berry, 1990; Milbrath, 1989; Shafer, 2006). Milbrath terms this viewpoint the "Dominant Social Paradigm", within which increasingly large sections of humanity operate. This version of progress is increasingly dependent on the power of technology, which is represented as of central and vital importance. Beginning in the 1970s, further sharpening of hypermodernity became possible and dependent on the ideology of neoliberalism, which Carter (2016) contends is a direct result of deliberate government and corporate ideologically-based interventions to promote its values (Smith & Watson, 2019).

We argue that this positioning of STEM and STEM education is highly problematic in four key ways: in its uncritical faith in economic growth; in its potential to narrow young people's ability to imagine a range of futures, in an alienation and disconnection from nature, and in the cooption of science in the service of STEM.

### **Uncritical faith in economic growth**

STEM places uncritical faith in economic growth arising from its unexamined neoliberal worldview and the internationalisation of economies that accompany globalisation. STEM proponents assume economic growth as a given good, in spite of the growing recognition of its ecological impacts on the world's ecosystems. As the climate crisis finally assumes a central position in global awareness, it has become very clear that continued growth, driven by development of the technologies and powered by fossil fuels, is unsustainable on a planet with finite material resources (Thiele, 2013), and we are forced to question the very notion of growth itself (Jackson, 2009; Washington & Twomey, 2016). Rethinking of the global economy towards concepts such as zero-growth, decoupling, de-growth, steady state, and ecological macro-economics necessary to halt the tide of continued ecological catastrophe is starting to take place. Examples are seen in the United States (Schlanger, 2019) and the United Kingdom (Jacobs, 2019), where political parties are putting forward Green New Deals. These economic systems are incompatible with current framings of STEM, hence are rarely mentioned or even understood within much of the STEM community. Even worse, they are often disparaged. As we write, we also see the impact of the COVID-19 virus compounding environmental concerns, as well as threatening the neoliberal economic ambitions (Hasan & Sachs, 2020). Can, in the end, it be a lesson in the importance of human survival over economic gain?

### **The narrowing of the imagination to envisage a sustainable future**

Our second concern, and perhaps resulting in more fundamental damage to our young people, is that STEM is complicit in the narrowing of young people's ability to envisage a range of futures beyond the technological. For some years, research has shown that young people's views of the future focus on hi-tech or environmental dystopias (Gidley, Bateman, & Smith, 2004; Smith, 2007). We argue that while STEM dominates discourses and practices in schools, forms of environmental education such as Education for Sustainability (EfS) (Australian Government Department of the Environment Water Heritage and the Arts, 2009) and Education for Sustainable Development (ESD) (United Nations, 2002; UNESCO, 2018) that are critical of economic growth, are becoming marginalised (Davis, 2012; Smith & Watson, 2019).

It is through EfS/ESD that the imagination to envisage preferable futures can be nurtured, and it was not that long ago that EfS/ESD was an important part of school education, with whole programs built around it, such as the Australian Sustainable Schools Initiative (AuSSI) (Smith & Watson,

2019). By sidelining EfS/ESD, deep understandings of the workings of natural systems are at best marginalised and at worse, ignored and not understood at all within the now dominant discourse of STEM education (see Smith and Watson, 2019 for a full discussion of this issue).

It is indeed ironic that, at the very moment we recognise the onset of the Anthropocene, we seem to have lost any coherent sense of what it means for humans to live within the ecological limits of the planet (Krabbe & Smith, 2019). Further, we appear to be losing our sense of relationship to the more-than-human world. Nature has become merely the backdrop that provides for human needs and desires. We believe that this marginalisation, a result of human selfish action, is highly problematic. In its aligning with the ideology of radical neoliberal market-driven responses to local and global environmental problems, and climate change in particular, STEM reflects the narrowing of the environmental agenda to what are essentially technological futures. In Australia, this has been echoed in increasingly acrimonious and divisive debates within the country's political system, where a vocal minority of parliamentarians skillfully manipulate the need to maintain coal mining in order to protect jobs in their electorates. This culminated in the now notorious incident in 2017 of the then Treasurer (and now Prime Minister) Scott Morrison bringing a lump of coal into parliament and announcing "This is coal. Don't be afraid, don't be scared" (Murphy, 2017).

Even after the devastating and unprecedented bushfires of 2019-2020 and under enormous pressure, the Prime Minister reluctantly and grudgingly admitted that climate change may have been a factor in their magnitude. His response, however, was a push for market-driven technology as the solution. In his address to the Press Club, Morrison declared:

So our climate action agenda is a practical one, it goes beyond targets and summits and it's driven by technology, not taxation... Our focus is also squarely on harnessing the power of new technology and allowing natural markets to operate, together with the desire and ingenuity of Australians to reduce emissions while keeping the economy strong .... Technology is key to driving down costs and identifying new economic opportunities for Australia, particularly for technologies providing storage and back-up to the electricity, industry and transport sectors... The answer is not more taxes and increased global bureaucracy, but practical change, driven by science and technology, that allows companies and economies to develop and commercialise new technologies that are accessible, affordable and scalable the world over (Morrison, 2020).

Recently, a new philosophy, Ecomodernism, has emerged. This is a bizarre and highly contested extreme extrapolation of the STEM agenda that purports to be aligned with a sustainable future (Asafu-Adjaye et al., 2015). Ecomodernists believe that we save nature by not using it and this is achieved by decoupling human society from the natural world by the processes of substitution and intensification. Substitution entails substituting the products of nature by moving up the "technology ladder" from wildlife

harvesting to increasing biomass for fuel to synthetic energy production. Intensification refers to increases in land efficiency such as intensifying agricultural yields and denser human settlement (Bliss, 2016). For Ecomodernists, decoupling does not just usher in an increase in material living standards while decreasing environmental impacts, but also physically disconnects humans from wild nature, which is to be left to revert to its pristine state.

There have been many critiques of ecomodernism; see for example, Bliss (2016), Fremaux (2018) and Hamilton (2015), who see it as a bizarre and wildly optimistic techno-fix view of the future. Others bemoan the Ecomodernist view of decoupling humanity from nature. These critiques arise from the view that humanity is an integral part of the web of life, and decoupling disrupts the very core of what it is to be human (Berry, 1999; Sideris, 2017; Smith, 2019). Were we to take the Ecomodernist path, we may leave ourselves with what Thomas Berry (1999) considers the only interpretation of our recent history: one of irony, where "our supposed progress towards an ever-improving human situation is bringing us to wasteworld instead of wonderworld" (p. 17).

### **Alienation and disconnection from nature**

Through shaping of the curriculum towards the technological focus of STEM and positioning STEM as the saviour of an uncertain future, we risk further disconnecting students and indeed ourselves, from deep engagement with nature. Through disconnection, we are able to forget that we live in an ecological system and that our social and economic systems depend entirely on that ecological system; that is, until ecological events such as floods, fires and ecosystem collapses, and now a coronavirus, threaten to overwhelm us. Crawford et al. (2020) have discussed the ways higher education institutions in 20 countries have made initial responses to COVID-19.

By charting the narrow path of STEM, a range of other ways of understanding and engaging with sustainable futures are excluded and not available to fire students' imaginations. Possible futures that are associated with relocalisation, self-sufficiency, reducing consumption and most importantly, engaging with the natural world, are less likely to be addressed. With technology increasingly portrayed as our aspiration and role model, the ability to envisage and create a rich, flourishing and abundant future becomes shoehorned into technological visions and we further become disconnected and alienated. In the view of Slaughter (2019), we need to recover a clear perception of how extreme and "abnormal" our present situation in relation to Earth really is. We believe STEM in its current form, is unable to provide this.

Already, we see this occurring. Even the language of nature has been hijacked by technology. Googling "Apple", "Blackberry", and "Amazon" shows the first pages provide nothing but technological devices, brands, and marketing. The terms "tweet", "cloud", "stream", which once were descriptions of natural phenomena, are now synonymous with the world of technology. Although we acknowledge that language is always in the process of evolving and

changing, these examples appear to be deliberate on the part of technology companies, rather than a natural evolution through usage.

A study by the UK National Trust (Love, 2019) found that just 1% of uses of the word "tweet" in conversation now refer to birdsong. While in the 1990s, 100% of mentions of "stream" meant "a small river", that has now fallen to 36%. Single-meaning natural words, such as "lawn", "twig", "blackbird", "fishing", "paddle", "sand", "paw" and "shell", also decreased in frequency among young people, and some, such as "bumblebee", have disappeared altogether. Love's study searched through two databases of language transcribed from conversations. The first, from the 1990s, comprised five million words and the second, from the 2010s, 12 million. He found that original uses of the word "cloud" dropped by nearly a quarter, with children's conversation moving away from the natural meanings of words in their vocabulary from about the age of 10.

Robert Macfarlane in his book *Landmarks* (2016) laments this narrowing of the language, which he describes as a moving towards a state of "un-knowing". For Macfarlane, the loss of nature language is more than just a loss of words. When something is no longer named, it ceases to have an identity, and accelerates the loss of our deep connections with the natural world and the leaching away from our experience of nature. Coupled with this change in language use, the amount of time our students spend online on electronic devices instead of out in nature, and the ever-present (and largely irrational) fear of being outside, has fueled alarming levels of disconnection and distancing from the natural world.

Our young increasingly inhabit hyperreal cyberworlds, where time and space are decoupled, and where speed and spectacle replace peace and stillness (Smith, 2007). *The child in the city* national research (2018) in the United Kingdom showed that children are playing outside for an average of just over four hours a week compared with 8.2 hours for their parents when they were children. Another study by the UK government study found that 10% of respondents have not been in a natural environment such as a park, forest or beach for at least a year. The conclusion is that although the importance of being in nature is well known, as discussed below, overall engagement with nature at least in the United Kingdom is low compared with previous generations. As the report puts it, we are "raising a generation of sedentary kids who would much rather sit on the couch with a game controller and Mario than be outside armed only with a stick and their imagination." Recently, a number of studies have linked time spent on social media and the rise of mental health problems (e.g., Rhiem et al., 2019). There is now even a psychiatric measure of Facebook addiction: Facebook Addiction Disorder (FAD) (Brailovskaia, Margraf, & Köllner, 2019; Da Veiga et al., 2019).

### **The role of science as part of STEM**

Our fourth concern with the rise of STEM is, as alluded to above, that STEM represents the latest incarnation

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1. A character in Nintendo video game



of an epistemology derived from the domination and instrumentalisation of nature to serve the needs and desires of humanity. By being subsumed into STEM, science itself is at risk of becoming the mere instrumental handmaiden of hypermodern technology and engineering, in other words, “technoscience” (Latour, 1988). In our post-modern hyperreal world, there is a profound loss of a sense of enchantment with nature, the sense that the natural world with its beauty and mystery, is a magical place. The role of science should be to instill a sense of awe, wonder and engagement with the natural world and the universe beyond: the sky at night, the turning of the seasons, the beauty of a leaf and the majesty of a forest. These are lost to those who do not experience them, and the result is a narrowing of the richness of the human imagination. Ironically, there is hope to be found in the outpouring of grief and concern for the native forests and wildlife destroyed during the recent Australian bushfires, a profound demonstration of how deeply we are still connected to nature.

Something is not functioning properly if humanity has changed the conditions for life to thrive, where multitudes of species are dying out and the climate is rapidly changing. Something is very wrong if we are continuing to educate children to continue to “conquer” nature. O’Sullivan (2001) remarks that: “the story of the modern epic... will be a story of progressive *disenchantment* from the natural world and all that this entails” (p. 81, author’s italics). For Thomas Berry (1990), our inner world is a response to the outer world. If our outer world is diminished of beauty, meaning, purpose, joy and relationship with the other-than-humans, we ourselves are diminished. We lose our imagination, we lose our intellectual development. Macfarlane (2016) agrees. He argues that “by instrumentalizing nature, linguistically and operationally, we have largely stunned the earth out of wonder” (pp. 25-26).

Berry is convinced that we cannot survive in our human order of being without the entire range of natural phenomena around us, and a number of writers believe that for recovery towards a sustainable and hopeful future to occur, modern humans need to frame a “New Story” (Berry, 1999; O’Sullivan, 2001; Eisenstein, 2018) of who we are in relation to nature. Berry’s (1999) great contribution has been to reinterpret and reframe science as an integration of science and spirit, as manifested in his New Story as a new creation story. In this New Story, humanity is profoundly at home in the universe, seeing it not from outside as a disinterested observer or controller, but as an intimate part of its creation and evolution. In Berry’s words, we are a communion of subjects, not a collection of objects. Interpreted and recast this way, science has the potential to reveal the human as deeply embedded within the magnificent story of a numinous, participatory, and interrelated universe. As he so aptly and evocatively puts it,

We see quite clearly that what happens to the nonhuman happens to the human. What happens to the outer world happens to the inner world. If the outer world is diminished in its grandeur then the emotional, imaginative, intellectual, and spiritual life of the human is diminished or extinguished (1999, p. 200).

Science has given us great gifts such as cosmology, which has opened up a deep and profound understanding of the origin and evolution of the universe and humanity’s place within it. The sciences of quantum physics, evolution, cosmology, systems theory, chaos and complexity have changed the way in which the organisational principles of the universe are understood. This view of the universe is one of an evolving, dynamic, ever-changing dance of destruction and creation: Teilhard de Chardin’s “cosmogenesis” (2004). This understanding has the potential to radically reshape the human-Nature relationship towards an ecological worldview that sees humans as an intimate part of Nature, part of the narrative of cosmogenesis. Cast this way, the science of the New Story is very different from the science that services STEM.

## Reconnecting - moves to a New Story

We have argued that STEM is potentially limiting and diminishing in its educational function. Hence it is heartening to read of moves towards saner, more grounded ways of educating young people in today’s world that do not entirely depend on framing the future as technological. Berry (1999) believes that our connectedness to the lifeworld, as sad as it may make us, is the only source of the sanity we need to attempt to survive individually and collectively. Though it is well known that time spent in nature has significant health benefits, both physical and psychological (e.g., Catholic Education Melbourne (2015), Forest Schools), we are engaging less and less. As the UK National Trust’s regional director, Andy Beer, quoted in Love (2019), puts it

As a nation we are losing our connection with nature. Nature connection isn’t just about playing outside, it means using all the senses - actively noticing nature, such as the way gorse growing wild by the coast can smell like coconut, how fog in the autumn can cling to your hair, how a spider web can sparkle on a dewy morning...

Through his book *The last child in the woods*, author Richard Louv (2013) has inspired the International Forest Schools movement to re-connect young children with nature. Indeed, a deeper connection to the planet and universe now appears to be the best antidote to the despair and confusion we feel in the face of mounting global crises. At first, connecting deeply to our ecological reality might these days seem to be a source of grief, given the conditions we face, but in reality, our connection to our immensely bigger context is the only sane place from which to observe the unfolding madness that surrounds us. Connection helps remind us of the sanity of physics, the vastness of the universe and time, the persistence of life and the resilience of evolution. Whether we survive or not (personally or collectively), our sanity in the present can only rely on our deep connectedness to life and the distance we can put between our perspective and the collective psychosis of our society culture and economy.

Children seem to be born with the ability to be connected, and one of the greatest gifts educators can give children is to build on this to help them learn to respect, to tread lightly, to be re-enchanted by the earth. As Berry puts it,

A child awakens to the universe: the mind of a child to a world of wonder, the imagination of a child to a world of beauty, the emotions of a child to a world of intimacy. It takes a universe to make a child, to educate a child; it takes a universe to fulfil a child. Sometimes you see children in an open field—they're cooped up so much they get a chance and they just run. Where to? They run to the horizon. You have to go chase after them to keep them from running into the river or somewhere. So the universe calls us forth into ourselves. That's the attraction. The universe is the greater self of every being in the universe (quoted in Reason, 2001).

There are now numerous moves worldwide that have taken note of our disconnection from nature and which are developing new, more connected and positive ways to help young people image a positive future. For example, a well-known school in the United Kingdom is developing an A-level alternative to teach teenagers to farm, forage and manage land sustainably through a "Living with the Land" course to promote self-sufficiency (Hazell, 2020). Throughout the world, students themselves, through the global strikes inspired by Greta Thunberg, are challenging governments' seeming unwillingness to take real action on climate emergency and are insisting on a different future for themselves and the planet.

It may be that STEM is a short-lived fad, and other more grounded forms of education that are consistent with the New Story, will emerge. Smith and Watson (2018) discuss pedagogies from two educational fields that offer important ways for students to critique STEM and enable them to consider deeper perspectives. First, the field of Futures Education provides ways for students to explore and think critically and creatively about probable and preferable futures (Hicks, 2017). Second, the principles of Education for Sustainability (EFS) (Australian Government Department of the Environment, Water, Heritage and the Arts, 2009) guide students to understand that while technology is important, it needs to be used in the service of the wider ecological understanding that the continued flourishing of life cannot be achieved by technology alone.

### **The Role of Higher Education in education for reconnection**

We have argued that a reconfigured New Story is needed to move students' imaginations from the narrow confines of the STEM agenda and that this must include reconnecting with nature in authentic ways. It is imperative then, that the University plays a central role in forging a thriving future for the human species and the others with whom we share Earth (Trencher et al., 2014). Although the role of university leadership in sustainable futures represents a vast topic that goes well beyond the scope of this paper (e.g. Haddock-Fraser, Rand & Scoffham, 2018; O'Sullivan, 2001; The Talloires Declaration, 1990), a few pertinent points should be made.

Krabbe and Smith (2019) argue that living in the Anthropocene "presents an urgent and critical challenge

to education systems in general and to universities in particular, and that the requirements, skills, needs, responses, mitigation and adaptation needed cannot be met by current models of education" (p.71). For Krabbe and Smith, a university responsive to the imperatives of the Anthropocene needs to be reconceptualised as a space where transformational education takes place. However, they believe that universities are better placed than most institutions to engage in the transformation to adapt to the Anthropocene. Education in the STEM subjects should be subject to critical examination of the role they are being asked to play, and overtly include an understanding of their ideological foundations. In particular, teacher education courses warrant consideration of their unexamined promotion of STEM, which then potentially carries over into school education and the narrowing of the imagination discussed above (Smith & Watson, 2019). Key to this will be the action and commitment of informed leadership to drive change, by challenging what is researched, what is taught and how (Eddy & Van Der Linden, 2006; Krabbe & Smith).

A conflict for universities is that they themselves are configured within a neoliberal ideology (Connell, 2013; Schulz, Sniedze-Gregory & Banfield, 2019; Smyth, 2017), so that fundamental ideological change is not likely to occur easily. But as Slaughter (2012) points out, in spite of their current configuration, universities still have inherent sympathy with their earlier traditions of social responsibility and knowledges outside the current tyranny of neoliberalism. They also retain a degree of semi-autonomy, and academics are generally globally-oriented, critical and post-conventional thinkers. At the faculty level, different perspectives can be considered.

### **Conclusions and recommendations**

In this article we have attempted to argue that STEM and thus STEM education, are inherently linked to a neoliberal, growthist view that increasingly places technology as the centre of our world. We contend that the vigorous promotion of STEM, although clearly having some role to play in education, is taking us and the students we teach further down a road that leads to social and environmental disaster.

Towards this end we call for a review of the promotion of STEM in its portrayal of technology as the saviour of our future. We call for technology to be grounded, appropriate and placed at the service of the flourishing of humans and the more-than-human world. We call on STEM education at all levels to move from its technoscience focus to be centred in dimensions that engage our students with the wider human experience of connection with nature. We call for science be given its prominent place in the lives of our students as a means to re-enchant the world, rather than complicit in the narrowing of their imaginations. Our hope is that lessons may be learned, and new perspectives forged from the coronavirus pandemic towards refocusing the growthist economic imperative towards an economy aligned with a flourishing for all life on earth.

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