

# SELECTING TEACHING THEORIES AND DESIGNING LEARNING AIDS FOR PUBLIC WORKSHOPS ON EMERGING TECHNOLOGIES

Deborah Carberry

A research paper submitted to the University of Dublin,  
in partial fulfilment of the requirements for the degree of  
Master of Science Interactive Digital Media

---

## DECLARATION

I have read and I understand the plagiarism provisions in the General Regulations of the University Calendar for the current year at: <http://www.tcd.ie/calendar>

I have also completed the Online Tutorial on avoiding plagiarism 'Ready, Steady, Write', located at <http://tcd-ie.libguides.com/plagiarism/ready-steady-write>

I declare that the work described in this research Paper is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

Signed: \_\_\_\_\_

Deborah Carberry

\_\_\_\_\_

Date

---

## PERMISSION TO LEND AND/OR COPY

I agree that Trinity College Library may lend or copy this research Paper upon request.

Signed: \_\_\_\_\_

Deborah Carberry

\_\_\_\_\_

Date

---

## ACKNOWLEDGEMENTS

I would like to thank:

My Supervisor, Radek Przedpełski for being an honest mentor and excellent teacher,

John Hallissey for supporting me and respecting my time,

Kelly Carberry for the stress busting workouts and cooking sessions,

Professor Mark Richardson for his generous spirit and wise council

and

Ronald Hughes for engaging with me in an ongoing debate about life and learning

---

## ABSTRACT

**Purpose:**

To explore suitable teaching theories and learning tools for a general workshop on the topic of future technologies.

**Design/methodology/approach:**

Quantitative and qualitative analysis of existing material

Design frameworks

**Highlights:**

A framework for comparing humans and technology

**Originality/value:**

A workshop outline

**Keywords:**

Educational discourses, Instructional design, Emergent technologies, Future narratives, Posthumanism.

**Paper Type:**

Research Paper

**Summary:**

The aim of this research paper is to explore appropriate educational theories and devise new learning tools for a proposed workshop. It will move across teaching theories such as design-based learning to learning theories such as radical constructivism and machine learning, with the goal of specifying a workshop on emerging technologies. These educational theories will also be used to explore the relationships between humans and technology and, learning.

The intended workshop design for which this preliminary work is undertaken is proposed for general consumption by an audience of mixed ages, interests, and abilities, and, for people from various backgrounds. Therefore, the content and activities specified will be those that are deemed versatile enough to satisfy multiple demographics simultaneously.

---

## Abstract

The objective of the proposed workshop is to enable participants to anticipate the future of human-technology and society-technology interactions. This would be occasioned by a learning experience where information modelling and design activities are catalysed for the provision of constructing future narratives. The goal is for learners to construe and expand their ideas within an active, nested framework.

This research paper will thread across multiple subjects ranging from biological evolution and neuroscience to food consumption and ubiquitous computing. These subjects will be woven into the discussion either because they form part of the proposed workshop design and/or because they provide context and meaning.

Whilst this research does not go so far as to implement or test the proposed workshop, an initial specification is set out to facilitate future work.

---

# CONTENTS

Declaration.....	i
Permission to lend and/or copy.....	ii
Aknowledgements.....	iii
Abstract .....	iv
Table of Figures .....	ix
Forward .....	1
1 Introduction.....	2
1.1 Aims, Objectives and Rationale .....	2
1.1 Literature Review.....	3
1.2 Methodology.....	6
2 Workshop Proposal .....	8
2.1 Design Constraints .....	8
2.2 Narrowing the focus .....	9
2.3 Proposed Workshop outline .....	11
3 Educational Discourses Analysis & Selection.....	13
3.1 Device 1 – Bands of key themes and metaphors .....	14
3.2 Device 2 – The X Axis.....	15
3.3 Device 3 – Clusters of Associated Discourses .....	16
3.4 Device 4 – The Y Axis.....	19
3.4.1 Studio-based learning.....	22
3.4.2 Situated Learning.....	22
3.4.3 Expansive Learning .....	23
3.4.4 Variation Theory.....	24
3.4.5 Social Constructivism .....	24
3.4.6 Design Thinking .....	25

---

## Contents

3.4.7	Design-based learning.....	26
3.4.8	Constructionism.....	26
3.4.9	Critical Pedagogy.....	26
4	learning.....	29
4.1	Forming.....	30
4.2	Sensing.....	31
4.3	Communicating.....	32
	Interim Summary .....	34
4.4	Learning.....	35
4.4.1	Radical Constructivism.....	36
4.4.2	Machine Learning.....	37
4.4.3	Cybernetics – Augmenting Life with the Power of technology .....	39
5	Conclusions & Future Work.....	42
5.1	Teaching theories for the proposed workshop.....	42
5.1.1	Learning Aids and Workshop Structure.....	42
5.1.2	Workshop Stages .....	43
5.2	Future Work.....	46
5.3	Final Note .....	47
	Works Cited.....	49
	Bibliography .....	51
	Appendix 1: Recommended Content for Stage 1 of the workshop .....	54
	Navigation & Self-driving vehicles.....	54
	Sustenance & Health.....	55
	Smart Fridges .....	55
	Health Apps .....	56
	Human-Computer Interfaces .....	57
	Augmented Reality.....	58

---



## Contents

Appendix 2 .....	61
Pia Tikka's Obsession as a case study for use in Stage 3 of the Workshop .....	61

## TABLE OF FIGURES

Figure 1 (Canvas): A 'Day in the life' Framework .....	10
Figure 2: Diagram of the brain, illustrating the location of the hypothalamus .....	10
Figure 3(Graph): Initial list of Educational discourses, indicating origin.....	13
Figure 4: Graph. Frequency of discourses arising in each group .....	16
Figure 5: Graph. Frequency of discourses arising in each major cluster .....	17
Figure 6: Graph. Frequency of discourses arising in each minor cluster .....	17
Figure 7: Graph. Suitable major clusters arising in the embeddedness group .....	18
Figure 8 (Graph): Suitable minor clusters arising in the embeddedness group.....	19
Figure 9: The Human & Technology comparative Canvas.....	29
Table 1: Technologies with the potential for integration into modern day hunting and gathering .....	11
Table 2: Discourse Reassignments .....	14
Table 3: Shortlist of discourses from the filtering exercise.....	20
Table 4: Tabulation of Davis and Francis learning metaphors.....	21
Table 5 Initial shiortlist of educational discourses .....	27
Table 6: Summary of Human and Technology comparative analysis .....	34
Table 7: Selected learning theories .....	36
Table 8: Machine learning paradigms .....	37
Table 9: Equivalent operations between brains and machine learning paradigms .....	38
Table 10: Summary of Human and Technology comparative analysis .....	41
Table 11: Sequence, name and proposed teaching theory for each stage in the workshop ....	42
Table 12: Subjects and technologies that require an introduction .....	43
Table 13: Examples of hardware and digital applications for stage 2 of the workshop .....	44
Table 14: List of Active learning techniques that are appropriate for Critical theory .....	45
Table 15: Design thinking methods suitable for use in the construction of future narratives.	46

---

## FORWARD

What would life be like if humans could no longer lie? If devices monitored the changing rate of our heartbeat, pupil dilation, cortisol levels etc.? Somewhere between sensor technologies and predictive computing resides the capacity to determine the biological reactions that humans exhibit to the situations and environments they find themselves in.

This paper, and the project it refers to, is inspired by Pia Tikka's enactive cinema installation, 'Obsession' 2005. Obsession can be described as a cinematic interactive narrative where the viewers 'decision' about what will happen next in the story is informed by their emotional response to what is happening currently. As Tikka explains,

enactive cinema, conceived of as a dynamical complex system, was initially associated to the idea of cybernetic control, but in the course of the study it became apparent that it was more like a system with emergent, self-organizing behavior, driven by the system's recursive two-way dynamics. Seen as such, the cinematic system receives emotional feedback from the spectator who, in turn, is influenced by the cinema. Such a system can no longer be authored in the first-order cybernetic sense of having full control, or first-order authorship. The author of such a complex system has to adopt the meta-level idea of constructing frameworks or environments within which individual narrative events can take place in an emergent manner, outside of the author's control, however within the ontospatial constraints set by the author. This new relationship, comparable to that of an architect to the spatial artifact she creates, can be characterized as second-order authorship, emphasizing the author's own proper impact on the system as part of the system, meaning, not as an external actor, but an enactor (Tikka, 2008, p. 287)

Enactive cinema is an example of an experience that resides at the interface between human and technological collaboration where humans relinquish their capacity to deceive the other. It also exhibits some of the characteristics of learning that apply to technology and humans alike which will be discussed later.

This paper is written for anyone with an interest in the topics we will address in the pages that follow, namely, emerging technologies and the future of human life, but more particularly, it is for those who are involved in devising new methods to illuminate these topics for others.

# 1 INTRODUCTION

## 1.1 AIMS, OBJECTIVES AND RATIONALE

The aim of this paper is to explore appropriate educational theories and devise new learning tools for a proposed workshop. The proposed workshop is intended to facilitate a public discourse on the topic of ‘The Future of Society and the Species’ where emerging technological innovations, and how these may impact on individual human life and society, will form the basis of the discourse. With a view to completing this preliminary work, the following activities will be undertaken:

- The selection of teaching theories that would be suitable for a workshop targeted at a public audience on the selected topics.
- The design and populating of a learning tool that could facilitate a learner to better understand the distinct characteristics of Information Technology.

Chapter 2 will introduce the proposed workshop.

Chapter 3 will focus on educational theories. A quantitative analysis will serve as the foundation of this chapter where the purpose is to shortlist and select suitable teaching theories for the specification of the proposed workshop.

Chapter 4 will undertake a thematic exploration of the similarities and differences between humans and technology to develop a framework for understanding the nature of information technology. This framework will double as a potential learning tool for the proposed workshop.

The rationale behind this research paper is the assumption that:

- Technological innovation is accelerating at a rate faster than our current education channels can evaluate the social and psychological impact of its outputs.
- Technological innovation is accelerating at a rate faster than our current education channels can proliferate knowledge on the topics.

The above assumptions are supported by the argumentation deployed by scholar Shoshana Zuboff (2019) to explain why a surveillance capitalist market form has been able to flourish. As Zuboff explains,

surveillance capitalism rose from invention to domination in record time. This reflects its ability to attract capital and its laws of motion, but it also reflects a specific strategy in which velocity is consciously deployed to paralyze awareness and freeze resistance while distracting us with immediate gratifications. Surveillance capitalism's velocities outrun democracy even as they outrun our ability to understand what is happening and consider the consequences... (Zuboff, 2019, p. 343)

The proposed workshop will seek to counter the effects of this *velocity*. It will seek to position a learning opportunity in the public domain where it is accessible to the many. It will be designed to harness human talents such as creativity and language for the rapid acquisition of new knowledge with a view to building the capacity for anticipating the future of technology in society.

### 1.1 LITERATURE REVIEW

The aim of this research is to support the future production of a workshop on the topic of emerging technologies. The literature review will be addressed by two relevant texts. The first is a paper by Katherine U. Hayles (2007) titled *Hyper & Deep Attention: The Generational Divide in Cognitive Modes* and the second is Chapter 6 of a book by Shoshana Zuboff (2019) titled *The Age of Surveillance Capitalism*.

Hayles' paper is concerned with a generational shift in cognitive styles in response to new media and leverages three topics; attention, stimulation and synaptogenesis, to illustrate and qualify this shift. The paper also provides examples of new teaching methodologies that are being tested as an alternative to the traditional form.

Attention was leveraged as the cognitive function to contextualise the generational shift. A contrast is drawn between 'deep' attention and 'hyper' attention. Deep attention requires a focus on a single information stream for a relatively long period of time whilst hyper attention produces an alternating focus across multiple information streams.

Deep attention, also known as executive attention, is the ability to tune out distractions and pay attention only to relevant information. Attitudes within academia towards deep and hyper attention are summarised by Hayles (p. 188) as follows, 'So standard has deep attention become in educational settings that it is the de facto norm, with hyper attention regarded as defective behaviour that scarcely qualifies as a cognitive model at all'.

Hayles references a study, *Generation M: Media in the lives of 8 – 18 years olds* (2004) that finds young people aged 8 -18 years old spend an average of 6.5 hours with media per day. This was consistent with findings from 5 years prior, so whilst the tendency to engage with media had not changed, the form and variety of the media has.

According to the study, over 60% of participants reported that they alternated between homework and other media either most of the time or some of the time. As alternating between tasks is inefficient, the study infers there must be another reason why students choose to do several tasks simultaneously instead of sequentially. Believing the preference can be explained by a preference for high levels of stimulation, Hayles (p.190) hypothesises that the ‘generational shift toward hyper attention can be understood as a shift in the mean towards the AD/HD end of the spectrum’. Stated another way, more people in the next generation are looking for greater levels of stimulation than in previous generations.

Hayles also asks an important question, how does media stimulation affect the brain? She reasons that it relates to brain plasticity and the human ability to reconfigure the nervous system in response to its environment. This reconfiguration is a process called synaptogenesis and consists of the pruning of the synaptic connections between neurons in the brain resulting in the strengthening and weakening of neural pathways. Synaptogenesis continues throughout life however it is greatest in infancy, becoming increasingly slower through adolescence and onwards. If synaptic connections co-evolve with one’s environment then, by extension, they co-evolve with one’s media consumption. Hayles concludes that, ‘It is not far-fetched to imagine that the trend towards hyper attention represents the brains cultural co-evolution in coordination with high-speed, information-intensive, and rapidly changing environments [...]’ (p. 194).

In turn, Zuboff articulates how the principle ordering of society is shifting from one that is characterized by the division of labour to one that is characterised by the division of learning. This is underpinned by surveillance capitalism where a strategy of declarations, velocities and the misappropriation of cultural signs and symbols have been harnessed for success of a new market form.

The division of labour can be likened to the streaming of the workforce into silos of different productivity goals. It depends on the principle of reciprocity, and in this way, it can be understood as the glue that holds society together. The shift from the division of labour to

the division of learning is a response to a sophisticated (or convoluted) mix of changing factors that include surveillance technology, data warehouses, computer algorithms and automation. The division of learning is about the concentration of knowledge in the hands of a small number of very powerful Companies. This is not consistent with the principle of reciprocity, without which, elements of society such as collective bargaining and public education become redundant.

Zuboff argues further that the division of learning has been privatized. Technology Companies perform very well on the same things they sell to their clients. They reduce the need for human capital, and, they scale using forms of non-human energy. However, very little can be achieved without a few brains of the human variety, and the largest of the technology companies are positioned to attract them. As a result, a disproportionate amount of intellect and talent is concentrated in a handful of very large technology companies. To illustrate, Google is now the top contributor to the most prestigious scientific journals (189).

This privatisation results in the loss of what Zuboff refers to as the double movement, where democratic institutions and civil society debate and negotiate with one another. Whilst society has exercised some effort to control this privatization via ‘privacy rights’ and ‘monopoly’ legislation, Zuboff (2019) believes that collective social action is the only means of reclaiming a democratic future.

Hayles and Zuboff view the changes posed by emerging technologies through very different lenses. Hayles discusses changes in human cognition and how these changes are presenting new challenges to education. She argues that the system needs to change to fit the student, not the student to fit the system and Hayles invites educators to think creatively and innovatively about new educational strategies. In turn, Zuboff discusses how education is being replaced by information, and more importantly, who has it, and who does not. As the technology Companies have access to more and more information relative to other social stakeholders, their need to negotiate is eliminated. Their advantage is that nobody else knows what is now known, fewer and fewer people know what was once known, further securing the advantage of those who now know. Zuboff argues that without collective bargaining and public education, society and its members lose *the means to combat*, without which, self-determination and democracy are eroded.

These texts raise many questions, in particular,

1. What does it mean to fit education to the student? Is it the same as fitting education to technology? What skills, if any, do we gain and sacrifice as a result? Is it productive or detrimental to human cognition to co-evolve with technology?
2. Are the traditional education institutions capable of evolving fast enough to keep up with the rate of change of technology? If not, do we need to develop new forms of educational institutions? If so, what form will they take?
3. And finally, is it possible to leverage education to build a reciprocal relationship with the Technology stakeholders? If so, is the public realm the most appropriate platform?

This research proposes a method to address the evolving inequality in the relationship between the technology firms and the public in support of a reciprocal relationship. Cognizant of the issues raised by Hayles about attitudes towards learning in formal education and mindful of Zuboff's belief that the relationship needs to be negotiated in the social domain, the method will centre on a workshop designed for the general public.

## 1.2 METHODOLOGY

This paper will set out several related discussions forthwith.

To begin, the workshop proposal will be introduced. As 'The future of the species' is too broad a topic for a single workshop the discussion will centre on narrowing the content to something more precise.

Next, an analysis will be carried out to shortlist and select several teaching theories that match the needs of the proposed workshop. This activity will be supported by an exceptionally well-crafted online tool called 'discourses on learning in education' (Davis, et al., 2020). This analysis will be quantitative as opposed to qualitative in nature. Features (traits, characteristics) of the learning theories will be used to extract a shortlist of teaching theories from a larger data set. The advantage of leading this selection activity with a quantitative approach is that it permits the assessment of a significantly higher volume of options than a qualitative approach would, thus saving time and/or increasing the value of the selected theories. Leading with a quantitative approach will not entirely negate the need to qualify the suitability of a teaching theory; however, it will significantly reduce the number of theories that need to be qualified than would otherwise be required.



Thereafter, and as part of the production of a possible learning tool, a comparative analysis will be carried out between the two primary actors of our research, humans and technology. Illustrating the similarities and the differences between these two actors will provide a foundation on their unique characteristics and, possibly, an understanding of how they currently relate to and interface with one another, and, how they might do so in the future. The primary device that will be employed for this comparative analysis is a framework that takes advantage of the personification device and a design principle called chunking.

Finally, and leveraging the selected teaching theories from the educational discourse analysis, a high-level specification for the proposed workshop will be set out.

## 2 WORKSHOP PROPOSAL

### 2.1 DESIGN CONSTRAINTS

There are several variables that are critical to the design of a learning experience, one of which is the learning space (Boys, J. 2011). It is intended that the proposed learning design will be appropriate for a wide range of learner types and learning spaces therefore the learning design will take the form of a workshop. Whilst a workshop is not as scalable as other formats, it is attractive because it supports a student-centred approach.

The workshop is intended for general consumption. Except for people under sixteen, the content and activities should be suitable for an audience of mixed ages, interests and abilities, and, for people from different backgrounds. Further, the workshop should offer opportunities for learning to people with and without prior knowledge of the topics. It should offer value for beginners and experts alike, working together in the same space on the same tasks at the same time.

The learning space is a feature of the learning design that will be given more attention in future work. At this preliminary stage, the research seeks to draw attention to the necessity of adequate spatial and material resourcing, and, to the link between moving and acting in a material landscape and the form(s) of thinking that ensue as a consequence. According to Boys,

in architecture [...] there has been a re-conceptualisation of the relationships between space and its activities in three important ways. First, [...] it is increasingly understood as non-representational or events-based; that is, meaning-making occurs through the activation of space by our bodies. [...] Third, encounters with and in space are neither cerebral nor corporeal but affective, where affect is not just articulated as ‘emotion’ but, as Thrift puts it, ‘affect is understood as a form of thinking. [...]’ (Thrift 2008: 175). Space is therefore one of our means of thinking about the world and of embodying thought into action (Boys, 2010, p. 6)

What opportunities and constraints the learning space affords a learner across both the physical and the media space, from access, availability, comfort, size, arrangement, surface space, routes, privacy, intimacy, sights, sounds, etc. are very important because humans are more than their brains.

Unfortunately, it is beyond the scope of this paper to specify, test and evaluate the proposed workshop however a high-level outline will be presented. This chapter will narrow the scope of the proposed workshop from ‘The future of the Species as a response to emerging technologies’ to something more precise.

### 2.2 NARROWING THE FOCUS

The aim of this paper is to propose a learning design that can facilitate a public discourse on the topic of ‘The Future of Society and the Species’, where emerging technological innovations and how these may impact on life and society will form the basis of the discourse. In chapter 7 of *Virtual Reality* (Greengard, 2019), Greengard sets out a section titled ‘A Day in the Life: 2030’ where fictitious character, Marc Smith, illustrates what shape life might take in a mixed reality (VR and AR) society. An excerpt of the section is as follows,

it’s 7am on a Tuesday morning. Marc Smith wakes up and places his augmented reality glasses over his eyes. He taps a button on the front of the frame and views a list of messages [...] The AR glasses use infrared technology to scan his wheat toast and scrambled eggs and provide a calorie count based on the volume of the food [...] Marc uses the glasses to order a ride-share vehicle [...] The glasses recognise that he is in a vehicle and thus provide contextually relevant information on request, including how long the commute to his office in downtown Seattle will take [...] it’s his job to ensure that a major building project is going according to plan. He straps on a virtual-reality headset and uses a laser pointer in the virtual space to enter a group meeting [...]. (Greengard, 2019)

On first thoughts, a day in the life appears to be a good framework to explore the future of living. However, after experimenting with a canvas (see Figure 1), it becomes clear that such a framework is insufficient. The problem appears to be that there is no real dependency between each of the stages of a day. Granted, travelling may be required to arrive at work, but there is no activity inherent in Travel that is necessarily inherent in Work. For example, we may anticipate a future of self-drive cars whilst also anticipating a future of learning and working from home. Indeed, the latter has become an uncanny reality during COVID19. But self-drive cars are not useful unless they are transporting goods, which is a necessary part of

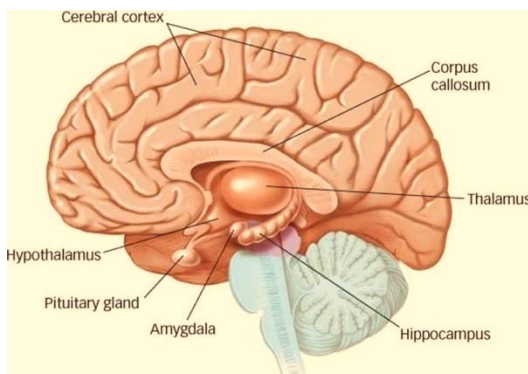
life but not necessarily something people do every day. As an alternative, employing one or more of life's basic needs as a topic could provide sufficient depth for joined up thinking.

**FIGURE 1 (CANVAS): A 'DAY IN THE LIFE' FRAMEWORK**

Waking Up	Morning Routine	Travel to (and from) Work/School	At Work / At School	Leisure Activities	Downtime Activities	Nightly Rituals
		Self -drive cars	From home			

The existence of biological rhythms was first detected in the early 18th century by a French scientist who shut a mimosa plant in a cupboard, and observed that its leaves still opened and closed to the rhythm of day and night; in other words, that its response was dictated, not by external light, but internally. (Fort, 2004)

**FIGURE 2: DIAGRAM OF THE BRAIN, ILLUSTRATING THE LOCATION OF THE HYPOTHALAMUS**



This phenomenon, which occurs in all living things is known as a circadian rhythm. Circadian rhythms are influenced by the hypothalamus which regulates activities such as eating, sleeping and procreating. The hypothalamus is located in the forebrain and is part of what is commonly referred to as the limbic system. The limbic system is the

centre of emotion and behaviour in the human brain and hence is involved in activities that are considered 'significant' to their owners.

A central idea in the study of 'life' is metabolic closure, which implies that "*all of the catalysts needed for an organism to stay alive must be produced by the organism itself, relying on nothing apart from food (and hence chemical energy) from outside.*" (Letelier, et al., 2011)

This positions the basic need to eat in a unique position relative to other basic needs such as sleep and procreation because it depends on the relationship one has with his/her immediate environment. (Similarly, we could extend this line of enquiry to society more

generally and analyse the landscape of ‘demand and supply’ for fossil fuels and renewables). When weighing up the range and types of digital products in the market place that target ‘diet’, it becomes evident that ‘eating’ offers the most advantageous opportunity for a more narrow focus on the proposed workshop theme.

This results in a shift from the more generalized theme ‘The future of Society and the Species’ to the more topical theme ‘The future of food consumption’.

From here, the question of what technology-based subject matter to include in the workshop could be answered more easily by the question, ‘what technologies may be integrated into modern day hunting and gathering practices?’ Table 1 below illustrates a range of technologies that answer this question and Appendix 1 introduces the technologies listed therein.

**TABLE 1: TECHNOLOGIES WITH THE POTENTIAL FOR INTEGRATION INTO MODERN DAY HUNTING AND GATHERING**

	<b>Topics</b>	<b>Technologies</b>	<b>Category</b>
1	Navigation / Logistics	Self-driving Cars	Ubiquitous Computing
2	Sustenance & Health	Health Apps, Smart Fridges	Ubiquitous Computing
3	Media Interface	Smart Screens, Smart Glasses, Smart Windscreens	Extended Reality

With a precise topic in hand, and a guide as to what content will need to be addressed, the next section will outline the proposed workshop.

### 2.3 PROPOSED WORKSHOP OUTLINE

Title: When the 1<sup>st</sup> World Urbanite no longer needs to Hunt and Gather

Topic: The future of food consumption

Format: Workshop

Audience: Adult, General

Structure: Three distinct sequential stages, namely, ‘Exploration’, ‘Design’ and ‘Sense-making’. Descriptions for each stage are as follows:

### ***Stage 1: Exploration***

The purpose of the Exploration stage is to allow for group bonding, and, to provide participants with a foundation on the topics which is necessary for participation in stage 2 and 3.

### ***Stage 2: Design***

The purpose of stage two of the workshop is to provide participants with an opportunity to imagine a range of possibilities for the future, based on current and emerging technological trends.

### ***Stage 3 – Sense-making***

The purpose of the Sense-making stage is to contextualise the designs from the previous stage (design stage), considering what is most probable based on broader societal and economic forces.

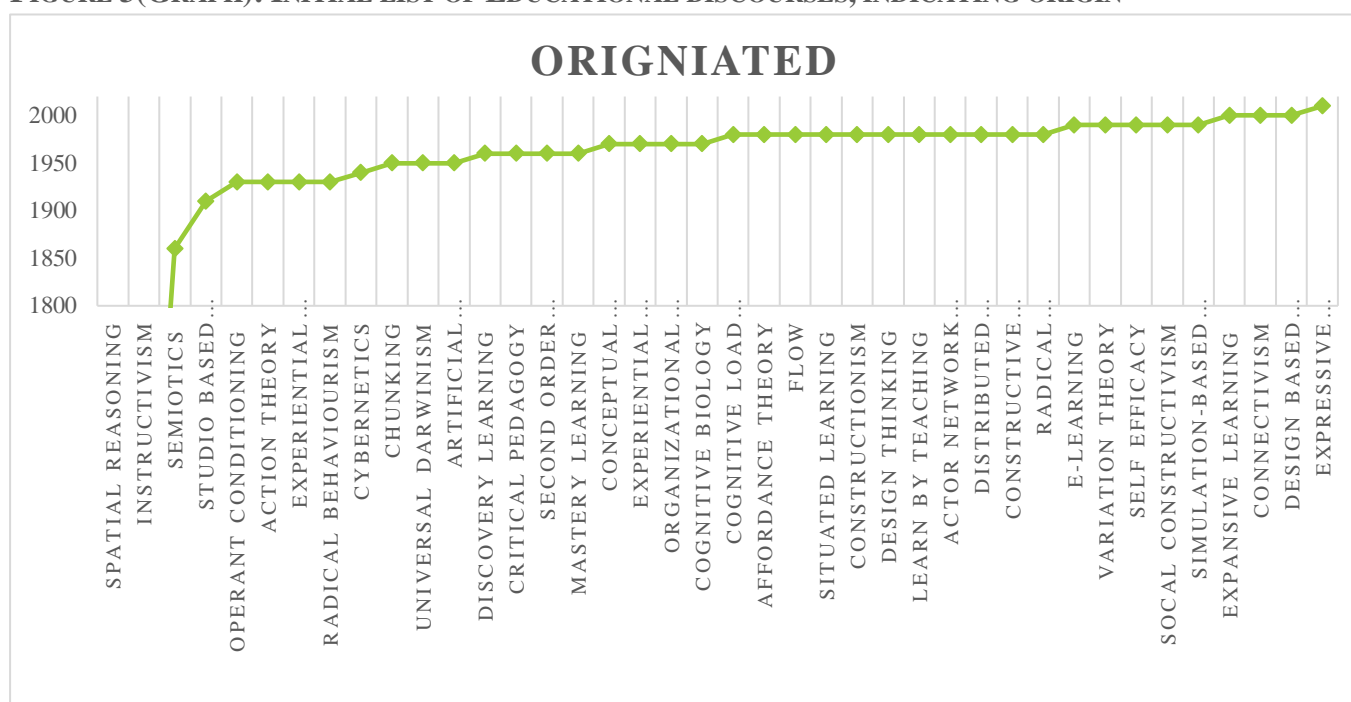
The next chapter will leverage a quantitative analysis to select suitable education theories with which to structure the proposed workshop and later, in the conclusion, a high level specification will illustrate how these theories can be mapped to the workshop.

### 3 EDUCATIONAL DISCOURSES ANALYSIS & SELECTION

This section will present an analysis of learning discourses with a view to shortlisting and selecting appropriate teaching theories. Learning theories are beginning to give way to educational neuroscience. However, neuroscience is a relatively new discipline and does not yet offer us sufficient insights that it could be singularly employed to inform the design of a learning experience. For this reason, this paper will employ educational theories, concepts and paradigms to inform the design of a workshop.

Brent Davis and Krista Francis of Werklund School of Education at the University of Calgary in Canada have devised an excellent online resource, which is effectively a survey of over 800 educational discourses, presented as an interactive Map. The survey aims to “highlight key differences among beliefs about learning and their entailments for teaching and research” (Davis & Francis, 2020). The map is organised according to five devices which permit a user to explore the relationships between the different discourses as a product of clustering and nesting of the discourses in relation to one another. An initial list of forty discourses were drawn up and are illustrated in Figure 3. Thereafter, and employing some backward engineering, four of five of Davis and Francis ‘devices’ were harnessed to narrow and shortlist appropriate discourses for further analysis and selection.

**FIGURE 3(GRAPH): INITIAL LIST OF EDUCATIONAL DISCOURSES, INDICATING ORIGIN**



On Davis and Francis map, the word discourse is used extensively to describe single theories, clusters of theories, clusters of clusters of theories, and, broad stroke characteristics (think isms) and approaches. To avoid confusion, single theories or part thereof will be referred to as discourses. Clusters of discourses will be referred to as clusters, and, clusters of clusters as major clusters. Character-based discourses will be referred to as groups and approaches as major groups. These assignments are outlined in Table 2 below.

**TABLE 2: DISCOURSE REASSIGNMENTS**

<b>Map reference</b>	<b>Our reference</b>	<b>Examples</b>
Single Discourses (theories etc.)	Discourses	Semiotics, Cybernetics
Clusters of discourses	Clusters	Developmental, Ecological
Clusters of clusters	Major clusters	Folk, Post-cognitivist
Characteristic discourses	Groups	Behaviourisms, Embodiment
Discourse Approach	Major groups	Correspondence, Coherence

This chapter will introduce the map devices for which Davis and Francis organised their survey of educational discourses. It will also demonstrate how the devices can be used to filter and reduce a larger list of discourses to a subset worthy of further analysis. The following tabulated data (titles and descriptions) are extracted directly from Davis and Francis online resource. The information contained in this research paper pertaining to the online resource has significantly more value when viewed alongside the online map, however, the format expressed here is sufficient for our purposes.

### 3.1 DEVICE 1 – BANDS OF KEY THEMES AND METAPHORS

Davis and Francis online resource includes several bands of key themes and metaphors. Themes and metaphors that are not applicable to the design of the proposed workshop have been greyed out in the ribbons below.

*Ribbon 1: Defining themes of Education*

Conservation Knowledge	of	Preparation (for Adult Life)	Enabling (the Individual)	Empowering (Democratic Citizens)	Anticipating (the future)
---------------------------	----	---------------------------------	------------------------------	-------------------------------------	------------------------------



*Ribbon 2: Key Metaphors of Teaching*

Delivering / Transmitting	Training / Conditioning	Guiding/ Facilitating	Occasioning / Orienting	Modelling/ Engaging / Involving	Designing	Mentoring / Empowering	Co- evolving
------------------------------	----------------------------	--------------------------	----------------------------	---------------------------------------	-----------	---------------------------	-----------------

*Ribbon 3: Key Metaphors of Learners*

Passive Recipient	Manipulable entity	Active Agent	Interactive Participant	Nested System
-------------------	--------------------	--------------	----------------------------	---------------

*Ribbon 4: Key Metaphors of Learning*

Getting	Encoding	Connecting	Construing	Adapting	Participating	Expanding	Living
---------	----------	------------	------------	----------	---------------	-----------	--------

The bands of Device 1 are presented as ribbons, two above and two below the map on which the list of educational discourses is situated. In this way, it is possible to quickly identify which discourses may be of more (or less) value for a given task.

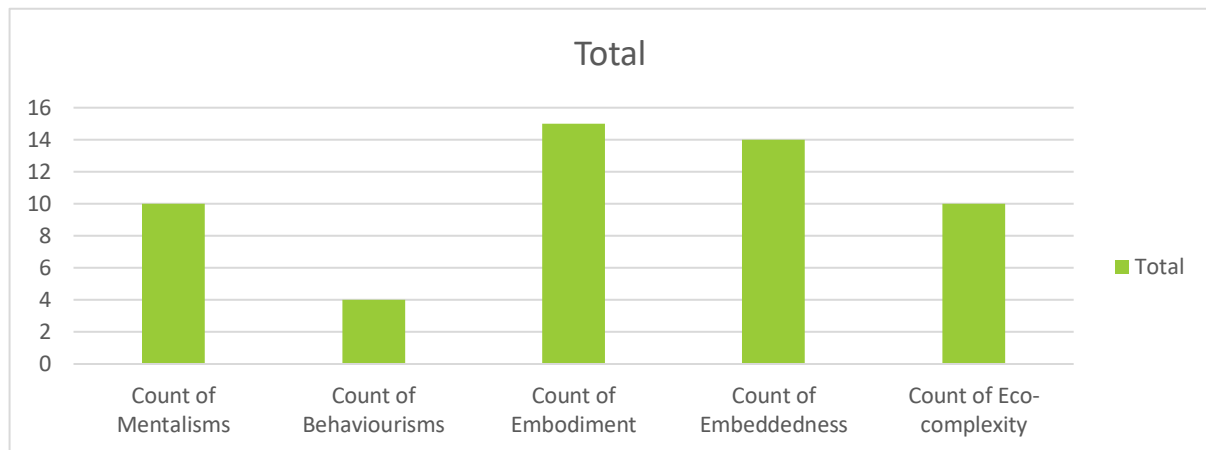
### 3.2 DEVICE 2 – THE X AXIS

Correspondence Discourses		Coherence Discourses		
Mentalism	Behaviourism	Embodiment	Embeddedness	Eco-complexity

A correspondence discourse views learning as something that happens in the mind that is separate from and representational of the real world. Correspondence discourses are broken down into two groups, Mentalism's and Behaviourisms. Mentalism's mainly concern one's internal subjective world. Conversely, behaviourisms are concerned with external observable behaviours. A coherence discourse views learning as an evolving process that is integral to a much broader system. Coherence discourses are broken down into three groups, embodiment discourses, embeddedness discourses and eco-complexity discourses. Davis and Francis roughly assimilate these groups to individual learning, collective dynamics and beyond-human matters, respectively.

Figure 4 illustrates the frequency of each of the groups generated by our initial list of discourses. Except for ‘behaviourisms’, all groups are well represented. It is worth noting that many discourses are qualified as belonging to more than one group. For example, experiential education falls into the mentalism, behaviourism and embodiment groups whilst Universal Darwinism falls into the embodiment, embeddedness and eco-complexity groups.

**FIGURE 4: GRAPH. FREQUENCY OF DISCOURSES ARISING IN EACH GROUP**



### 3.3 DEVICE 3 – CLUSTERS OF ASSOCIATED DISCOURSES

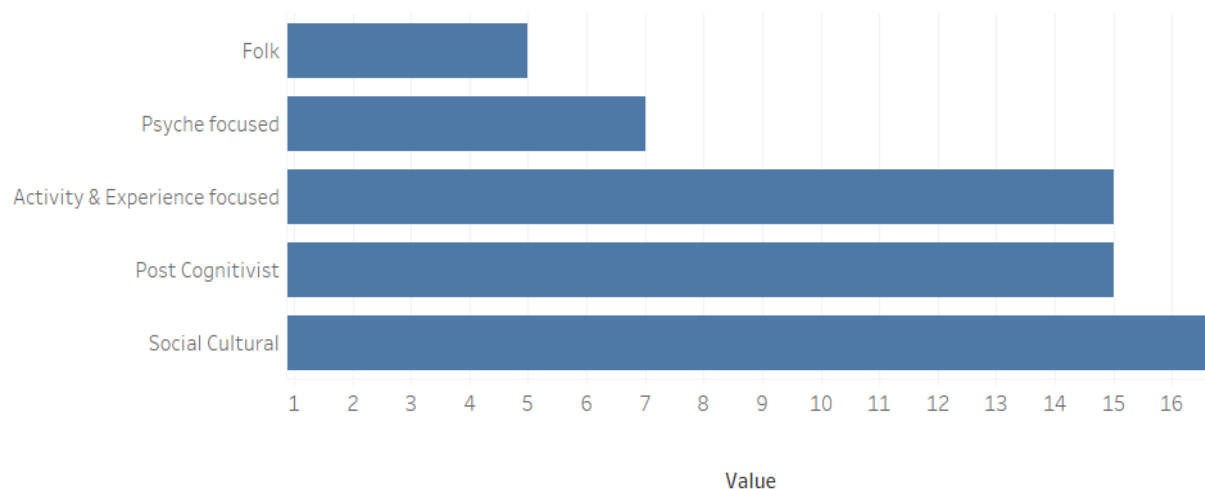
Davis & Francis online map highlights 30 thematic clusters. Many more clusters were identified, however they elected to promote the ones that “*seem to have some currency*”. (Davis & Francis, 2020)

There are five major clusters, which in turn, house or overlap with several smaller clusters. Figure 5 illustrates the frequency of the major clusters generated by our initial list whilst Figure 6 illustrates the frequency of the minor clusters. Here, we can begin to build a picture of where the focus of the initial list resides.

According to Figure 5 the more popular major clusters are Activity focused, Post Cognitivist and Social Cultural in nature. Figure 6 includes seventeen minor clusters. Of the seventeen, Learning collectives, Emergent design, Individuals in group settings and Emergent complexity clusters are most prevalent. Given that one of the objectives is to design a learning experience for a diverse audience, this skew towards activity and social discourses is appropriate.

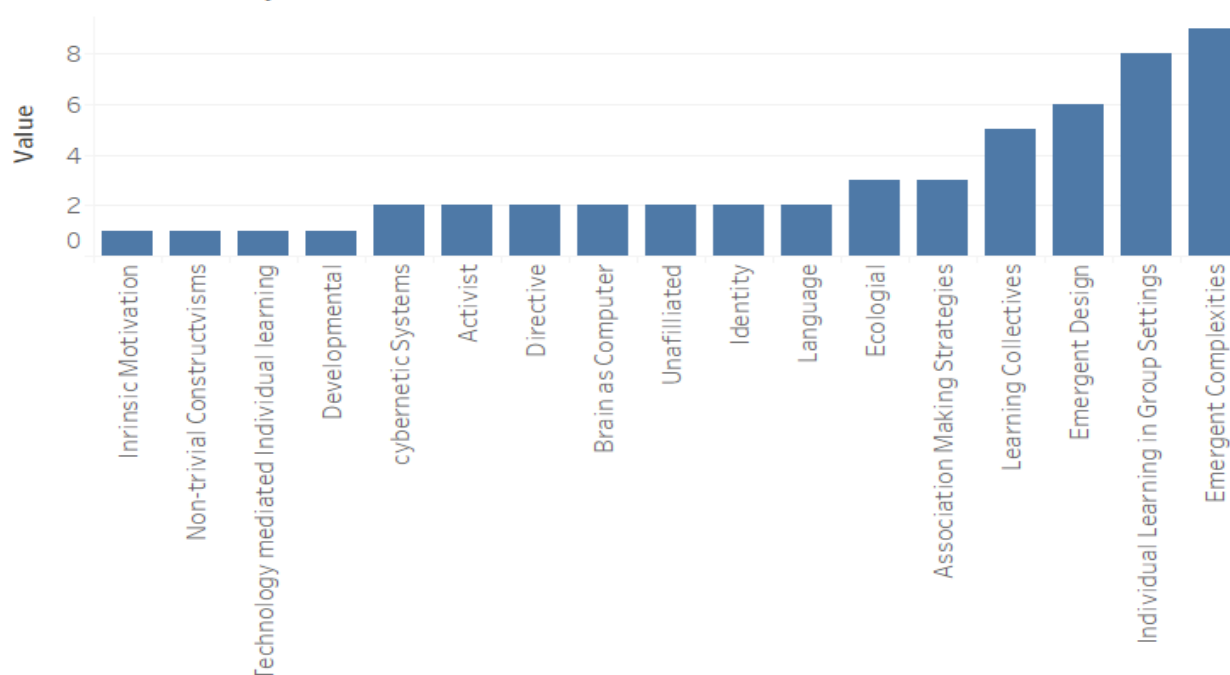
**FIGURE 5: GRAPH. FREQUENCY OF DISCOURSES ARISING IN EACH MAJOR CLUSTER**

Major Clusters by Count



**FIGURE 6: GRAPH. FREQUENCY OF DISCOURSES ARISING IN EACH MINOR CLUSTER**

Minor Clusters by Count



Using devices 2 and 3, elimination of multiple discourses from further analysis can now commence.

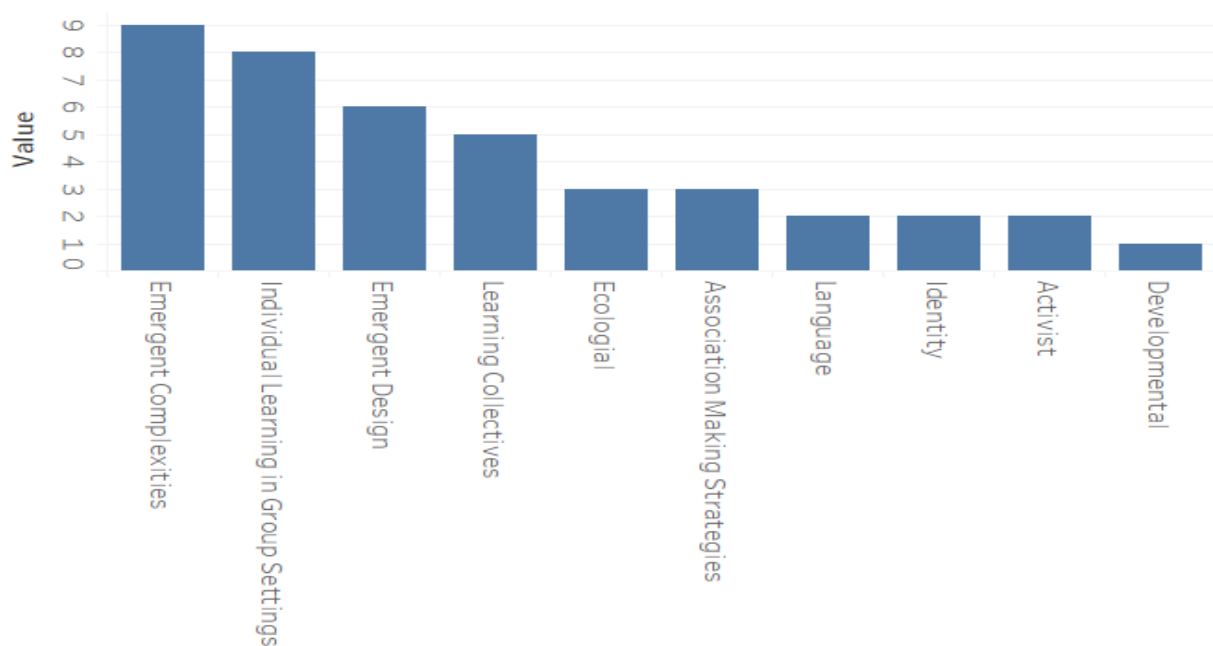
Mentalism's concern the learner's internal subjective world. As a workshop assumes a social dimension clusters that fall solely into the Mentalism category can be discounted from

further analysis. The Behaviourism and Embodiment group are not characteristic of a workshop format either. Behaviourist discourses are concerned with observable actions only. They lean on extrinsic motivation methods such as competitive grading systems to promote learning. As the workshop is intended for individuals who are genuinely interested in the topics, extrinsic motivation methods are not required. Embodiment discourses are concerned with individual learning, not group learning. As workshops are group-based events, methods for ‘learning alone’ are not applicable.

On the other hand, educational clusters that arise from within the Embeddedness group should yield some interesting ideas due to their focus on learning that occurs within collective dynamics. Figure 7 indicates the ten minor clusters that qualify as members of the embeddedness group.

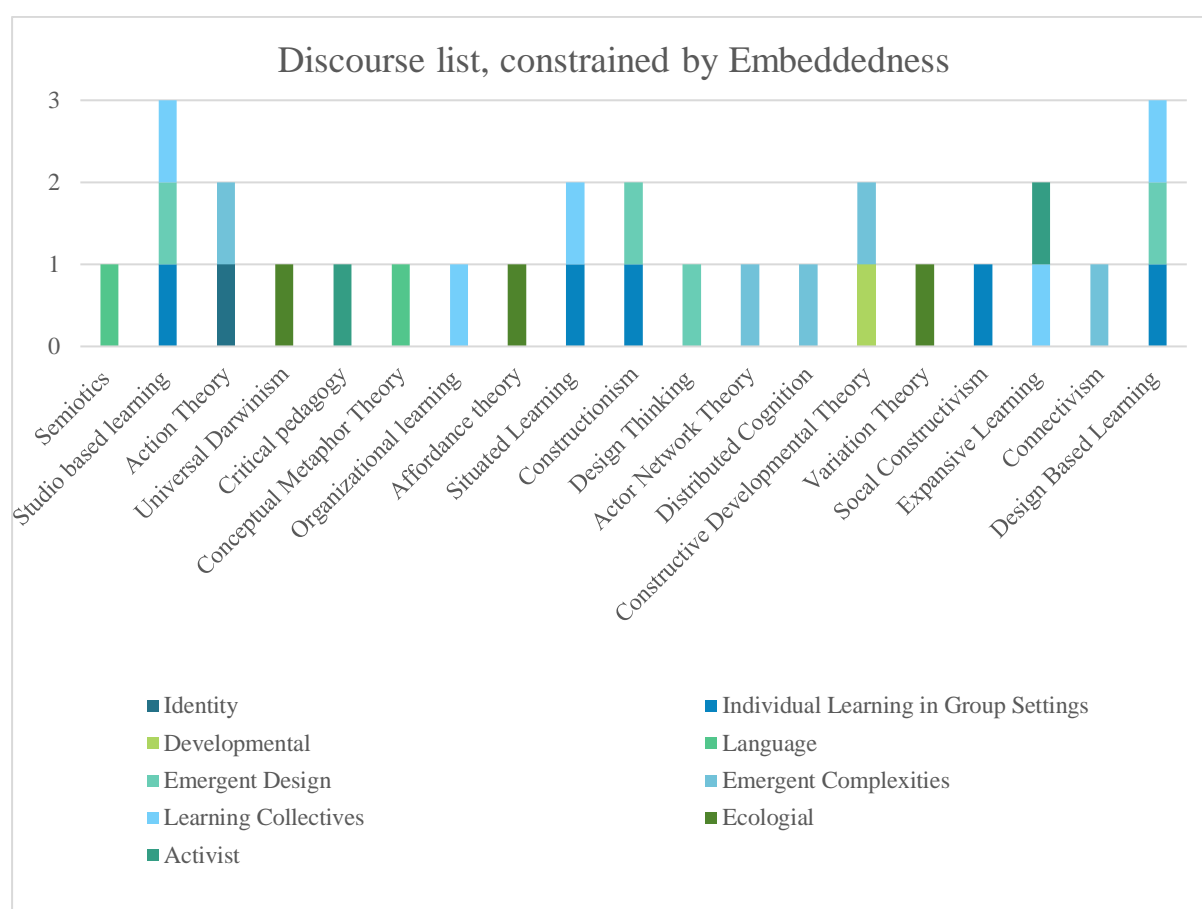
**FIGURE 7: GRAPH. SUITABLE MAJOR CLUSTERS ARISING IN THE EMBEDDEDNESS GROUP**

Minor clusters that qualify as an Embeddedness discourse



Excluding all educational theories that fall outside our region of interest has the effect of reducing our list from forty discourses to nineteen, illustrated in Figure 8 below.

**FIGURE 8 (GRAPH): SUITABLE MINOR CLUSTERS ARISING IN THE EMBEDDEDNESS GROUP**



### 3.4 DEVICE 4 – THE Y AXIS

1	Influencing Learning
2	Interpreting Learning

Device 4 categorises the discourses according to whether they are concerned with influencing learning or interpreting learning. In many, but not all cases, teaching theories arise in the influencing learning category whilst learning theories arise in the interpreting learning category. Notwithstanding, not all discourses qualify as either a teaching or learning theory. They range in their quality from theories to perspectives, and principles to descriptions.

Thinking about educational theories in terms of whether they are a learning theory or a teaching theory is very useful. Learning theories seek to understand how learning happens whilst teaching theories seek to devise suitable methods to facilitate this learning. It is beyond the scope of this section of the paper to review theories of learning therefore only theories of

teaching will be considered further. By excluding learning theories, we arrive at a shortlist of ten discourses, just a quarter of the number we originally started with.

This concludes the filtering exercise, of which the shortlist is outlined in Table 3 below.

**TABLE 3: SHORTLIST OF DISCOURSES FROM THE FILTERING EXERCISE**

No.	Discourse	Minor Cluster(s)
1	Studio-based learning	Learning Collectives, Individual Learning in group settings, Emergent Design
2	Organizational learning	Learning Collectives
3	Situated Learning	Learning Collectives, Individual learning in group settings
4	Variation Theory	Ecological
5	Social Constructivism	Individual Learning in Group Settings
6	Design Based Learning	Learning Collectives, Individual Learning in group settings, Emergent Design
7	Design Thinking	Emergent Design
8	Constructionism	Individual learning in group settings, Emergent Design
9	Critical pedagogy	Activist
10	Expansive Learning	Learning Collectives, Activist

It is unlikely that each of the discourses in the shortlist will be appropriate for a learning event such as the one being proposed however Davis and Francis map has nothing more to add to our analysis. To further evaluate the suitability of each of the teaching discourses for our intended purpose, items in the current shortlist will be reviewed qualitatively forthwith.

Davis and Francis present each of the educational discourses in their survey according to several parameters, or metaphors, as follows:

- Knowledge is
- Knowing is
- Learner is
- Learning is
- Teaching is

They also provide a short synopsis and commentary for each. This, and other literature will now be consulted to ascertain which of the ten shortlisted discourses are most appropriate for application in the proposed workshop.

**TABLE 4: TABULATION OF DAVIS AND FRANCIS LEARNING METAPHORS**

	<i>Noun</i>		<i>Verb</i>		
Principal Metaphors	<i>Knowledge is</i>	<i>Learner is</i>	<i>Knowing is</i>	<i>Learning is</i>	<i>Teaching is</i>
Learning Collectives	situation-relevant actions and interpretations	a collective entity (defined by a purpose or a task)	effective contributions to joint activities	elaborating current possibilities	coaching, supporting
Ecological	scope of systemic possibilities	<i>integral element of an ecosystem</i>	individual- and system-maintaining functioning	adapting to maintain relational integrity	<i>designing experiences (orienting, juxtaposing)</i>
Individual Learning in Group Settings	scope of possible actions and interpretations	a collaborator	contributing appropriately	developing understanding and/or skill	supervising, facilitating, guiding
Emergent Design Discourses	evolving web of possible actions and interpretations	designer(s)	acting and designing (according to one's experience)	elaborating, innovating (iterative, emergent)	orienting attentions, engaging, occasioning
Activist	power to act	a citizen	acting	acculturation	awareness raising

In Table 4 the metaphors have been further defined based on whether they fall more firmly into a description as a noun or a verb.

The *knowledge is* and the *learner is* metaphors can be conceived of as object-based or noun-based. Except for learning collectives, all the groups define *knowledge* in terms of possibilities, be it possibilities in relation to systems, actions and/or interpretations. With the exception, again, of learning collectives, all of the groups define *the learner* as an object within a broader landscape, i.e. as a collaborator in the 'Individual learning in group settings' cluster, and, as a citizen in the 'Activist' cluster.

*The Knowing, learning and teaching* metaphors can be conceived of as verbs or action based. Whilst there are many similarities and shared characteristics across the five groups in relation to the action-based metaphors, it is here we find more variation among the different clusters.

At first glance, the ‘learning Collectives’ cluster does not appear to be a very good fit for the proposed workshop. To begin, it falls short on the two object-based metaphors. Learning collectives describe *knowledge* as situation relevant, and *a learner* as a collective. It also falls short on one of the action-based metaphors, *teaching*, which is described as coaching and supporting. As the proposed learning design is not situated within a particular context and coaching is not applicable, we will exclude any discourse that falls solely into this cluster from further analysis. This results in the exclusion of the *organizational learning* discourse. This also casts doubt on three more of the shortlisted discourses; *studio-based learning*, *situated learning* and *expansive learning*. These discourses will be screened first for suitability before we proceed to evaluate the remaining potential discourses.

### 3.4.1 STUDIO-BASED LEARNING

Studio-based learning stems from the medieval era when apprentices learned trades such as Art and Craft under the instruction of a Master. Studios emerged in mainstream education in the early 1900’s, John Dewey’s school in Chicago serving as an early example.. Studio-based learning is particularly suited to the pursuit of mastery in a specific skill area, such as Art, Architecture, Dance or Yoga. The learning design for which this paper serves is not targeted at an audience with or pursuing mastery of a skill or topic, therefore, studio-based learning is a less than ideal choice for our purposes.

### 3.4.2 SITUATED LEARNING

*Situated learning* originated in the 1990’s. Two key proponents of the theory are Jean Lave and Etienne Wenger. In common with *studio-based learning*, the focus is on the pursuit of gradual development or mastery of more expert skills. The difference between *studio-based learning* and *situated learning* is the context. Whereas *studio-based learning* can occur in advance of professional engagement or in incubation at a workplace, *situated learning* is more prevalent in workplaces with mixed ability teams working on common projects. The proposed learning experience is not situated therefore situated learning is a less than ideal discourse for our purposes.



### 3.4.3 EXPANSIVE LEARNING

*Expansive Learning* holds that the acquisition and participation metaphors of learning are insufficient (Engeström & Sannino, 2010). *Expansive learning* positions itself according to four parameters, or dimensions, the learner, the cultural, the structural and ‘knowledge and concepts’. The learner dimension defines education as something that is individual or collective. The cultural dimension considers whether the education process is about preservation or transformation. The structural dimension identifies whether education is vertical (i.e. occurring along a uniform scale of competence), or horizontal (i.e. a hybrid of competencies). And, the ‘knowledge and concepts’ dimension defines education as either acquisition and creatively orientated, or, formation orientated.

Describing *expansive learning* according to its own dimensions, it serves learning needs among a collective who require culture transformation, in a hybridized environment for the purpose of forming new knowledge and concepts. (Engeström & Sannino, 2010) . A suitable application of this learning pedagogy would be in hospitals, schools, workplaces and other organizations that have and will continue to be disrupted by COVID19.

Whilst structural dimensions of our proposed learning design are consistent with *expansive learning*, i.e. we are employing hybridised competencies, we do not have similar needs in terms of the cultural dimension or the ‘knowledge and concepts’ dimension. For instance, the content that we will share with participants will be well known ahead of time. This is not the case in a situation that would benefit from an *expansive learning* approach. And, whilst the participants of the proposed learning design will engage in the creation of future narratives, they are of no immediate consequence. In other words, the participants are not required to implement anything. Without that need to disrupt a process that has become obsolete for something new that has value, *expansive learning* offers relatively little value to this project.

Taking account of the high level learning focus, target audience and environmental context of each of the discourses that fall into the collective learning cluster, and recognising that they are not compatible with the proposed workshop, *studio-based learning*, *situated learning* and *expansive learning* can be eliminated from further consideration. Discourses arising in the four

remaining clusters, Ecological, Individual Learning in Group Settings, Emergent Design Discourses and Activist, will now be assessed for suitability.

### 3.4.4 VARIATION THEORY

*Variation theory* originated in the 1990's. According to (Royea & Nicol, 2019, p. 565), 'This theory has emerged as a theoretical framework to understand learning (e.g. Runesson 2006), design lessons (e.g. Fraser and Linder 2009), and analyse lesson outcomes (e.g. Lo, Chik, and Pang 2006)'. (Royea & Nicol, 2019) *Variation theory* exploits several principles from cognitive science that relate to mental processes such as working memory, attention and the interest that can be inspired in learners via the use of novel approaches and content. As a result, it can offer advice on teaching techniques that reduce cognitive load and/or channel attention.

*Variation theory* is a suitable teaching theory for the proposed learning design, particularly in the ways it may be applied in the design of suitable content and tools, and their corresponding format.

### 3.4.5 SOCIAL CONSTRUCTIVISM

*Social constructivism* originated in the 1990's. Key proponents of the theory include Vygotsky and Bruner.

*Social Constructivism* is a teaching theory that builds on the cognitive constructivist tradition. The most fundamental principle of *constructivism* is that humans construct their own knowledge structures and mental models through individual experience and/or observations. This metatheory is influenced by Jean Piaget's theory of cognitive development which proposes that humans cannot immediately understand and use information that is given to them. *Social constructivism* departs from the cognitive perspective with the fundamental principle that all knowledge is social in origin.. As outlined by Talja,

Whereas Piaget suggested that individuals construct knowledge through their actions in the world, Vygotsky stated that understanding is social in origin. From the Vygotskian point of view, knowledge formation and the development of knowledge structures take place within a socio-cultural context. (Talja, et al., 2003)

Social interaction, and language in particular, is a primary approach to learning in *social constructivism*. Fleck (1986) discusses the idea of how different thought-collectives talk next to one another, as opposed to with one other. He argues that this is the result of their different thought-styles and hence, deduces a link between language and thinking. As he explains,

scientist, philologist, theologian, or cabbalist can perfectly communicate with each other within the limits of their collectives, but the communication between a physicist and a philologist is difficult, between a physicist and a theologian very difficult, and between a physicist and a cabbalist or mystic impossible. The subject of conversation does not play a decisive role, because on an apparently identical subject, e.g. a certain disease or celestial phenomenon, a physicist will understand a biologist, but will be unable to come to an understanding with a theologian, or a gnostic. (Fleck, 1986, pp. 81-2)

Construing meaning through language-based discourse will be an important feature of the proposed workshop, however, as the intended audience will be drawn from diverse backgrounds, it will be important to be mindful when sourcing or constructing texts that they are intended for multiple tribes.

### 3.4.6 DESIGN THINKING

*Design Thinking* is a discourse that emerged in the 1980's. Two key proponents of the discourse are John E. Arnold and Bruce Archer. There is no single definition for design thinking. It possesses several characteristics; Human-centred, possibility driven, option focused and iterative. As a methodology for collaborative design work, it is versatile in the range of applications it can be applied to:

[...] we see it helping impoverished farmers adopt new practices in Mexico, keeping at-risk California teenagers in school, reducing the frequency of mental health emergencies in Australia, and helping manufacturer and government regulators in Washington find common ground on medical device standards. (Liedtka, et al., 2017)

The workshop for which this paper refers is intended to be accessible to all. *Design thinking* does not require users to possess specialist skills or knowledge to participate. The workshop

will address the subject of the future, the unknown. *Design thinking* is agile, that is, it is suitable for application in situations where problems are not yet known or not yet well defined. These attributes make design thinking an excellent choice for our purposes.

*Design thinking* employs popular design techniques such as brainstorming, storyboarding and persona design. It also employs a framework that is consistent with the *design-based learning* discourse that will be introduced forthwith.

### 3.4.7 DESIGN-BASED LEARNING

*Design-based learning* originated in the 2000's. A key proponent of the discourse is Doreen Nelson. *Design-based learning* is the construction of artefacts through body-active problem solving, using the iterative cycle of design, prototype, test and re-design. *Design-based learning* harnesses design skills and soft skills to facilitate learning and is a suitable theory for the design stage of the proposed learning design.

### 3.4.8 CONSTRUCTIONISM

*Constructionism* emerged in the 1990's and its key proponent is Seymour Papert. It is a problem-based learning approach that leverages the activity of making things to produce mental states such as immersion or flow. In his book, *The Children's Machine* (1993), Papert states that 'learners construct new knowledge most effectively when they are in the process of constructing something external which they can examine for themselves and discuss with others'. Papert developed the theory to promote a desire among students to learn mathematical skills. Today, it is often employed to teach technology related subjects such as programming, video game development and robotics projects.

Whilst *constructionism* could be employed as a method for our workshop, it is probably more suited to 'making' projects that occur over multiple activity sessions. In other words, it is consistent with mastering new skills.

### 3.4.9 CRITICAL PEDAGOGY

*Critical pedagogy* originated in the 1960's. Two key proponents are Paulo Freire and Henry Giroux.

according to Freire, critical pedagogy affords students the opportunity to read, write, and learn for themselves--to engage in a culture of questioning that demands far more competence than rote learning and the application of acquired skills. (Giroux, Henry A .2010)

*Critical pedagogy* is concerned with power structures and is political in nature. Unlike most educational theories, it qualifies the metaphors of Knowing, Learner and Learning according to two polar definitions. Knowing can be mindless or conscientious. Learning is the process of becoming either acculturated or aware. A learner can be a pawn or an agent of change.

The proposed workshop embraces *critical pedagogy* in its purpose as well as its form. It demands that the participants develop their awareness of the themes and become engaged, at least imaginatively, in the shape of the future.

Table 5 summarises key features of the outstanding discourses from the educational discourse analysis.

**TABLE 5 INITIAL SHIORTLIST OF EDUCATIONAL DISCOURSES**

<b>Discourse</b>	<b>Application</b>	<b>Method</b>
Variation Theory	Learning Design	Design content for optimised sense making with a view to increasing ease and speed of knowledge acquisition
Social constructivism	Learning Activity	Languaging, reading, writing
Critical Theory	Learning Activity	Languaging, reading, writing
Constructionism	Learning Activity	Build artefacts
Design Thinking	Learning Activity	Design process
Design based learning	Learning Activity	Design process, Building artefacts

The workshop will be more dynamic if we consult three or four teaching theories. Whilst each of the six remaining discourses are viable for the proposed workshop, there would be redundancy in applying all six. Further, some of the discourses appear to have more to offer to the proposed design than others.

*Constructionism* shares a lot of common ground with *design thinking*, albeit it is more focused on artefact production and regular practice. *Design-based learning* is an approach that can be employed within *design thinking*. For these reasons, *design thinking* offers the most advantage of these three options.

Meanwhile, *social constructivism* methods overlap with those of *critical theory*, although *critical theory* is more expansive in its focus. As the topic of the workshop relates to the future, *critical theory* offers the most advantage of these two options.

*Variation theory* stands apart from the rest with a focus on cognitive processes such as perception, affordances and instinct. *Variation theory* has the power to inspire the design of engaging resources for the next phase of the project, i.e. as part of future work. For this reason, it is selected as the third teaching theory for the proposed workshop.

To summarise, the recommended teaching theories for the proposed workshop are as follows, *Design Thinking*, *Critical theory* and *Variation theory*. *Design thinking* has been selected to support the learning process, *critical theory* has been selected to support the learning objectives and goals whilst *variation theory* has been selected to support the production of learning tools and resources.

It is important to point out at this point that each of these theories require a good handle on the background knowledge that informs them, and in some cases, other skills and competencies too.

## 4 LEARNING

The workshop seeks to enable participants to anticipate the future of humans and their societies in response to new and emerging digital technologies. To achieve this the participants will need to understand something about the comparative nature of humans and technology. This chapter presents a framework that has been designed to serve this specific purpose. This chapter is also intended to illustrate the quality of the framework as a learning tool through the process of populating the four quadrants of which it is comprised.

Design methods were employed by the author for the purpose of constructing the framework which is intended to permit a systematic comparison of human and machine intelligence. An initial brainstorm produced a list of about fifteen features that could be ascribed to humans. Following a grouping exercise of the features (chunking), hierarchical ordering, and, a validity check against their appropriate application to technology, Forming, Sensing, Communicating and Learning emerged as a suitable model for a comparative analysis.

Personification was guaranteed as an inherent feature of the framework because the design commenced with a list of features that can be ascribed to humans as opposed to technology. As described in the methodology section above, it is anticipated that personification will permit rapid acquisition of knowledge by the learner about the actors.

**FIGURE 9: THE HUMAN & TECHNOLOGY COMPARATIVE CANVAS**

Forming (Body)	Sensing
Communication	Learning

The following sections of the paper will set out to populate the four quadrants in what can be referred to as a human and technology comparative Canvas.

## 4.1 FORMING

Forming can be understood as a structure or body.

Each human life inhabits their own body, which is a biological machine capable of motion. In terms of form (as opposed to organs) most human bodies consist of a head and neck, back and chest, arms and hands, and, legs and feet. Humans belong to one of thirty-five phyla in the animal kingdom called chordates which first appeared on earth about 540 million years ago during the Cambrian explosion. What all chordates share is that at some point in their lives, they all possess a notochord, a hollow nerve tube, gill slits and a tail. Except for the hollow nerve tube, humans lose, or transform these features during embryonic development.

What distinguished chordates from their predecessor, probably a worm similar to an acorn worm, is that they could swim. Both chordates and acorn worms possess gill slits and notochords, however only their gill slits are homologous (sharing identical genetic code). What is critically different between the two is that an acorn worm does not possess a hollow nerve tube. Instead, it possesses a diffuse epidermal ‘nerve net’. In other words, the acorn worm does not have a central nervous system (CNS) like chordates do. Rather, their nervous system is distributed like a net, just under the surface of their skin.

the key to the question ‘Should this animal have a head?’ turns out to be: ‘Does this animal have a front?’. And the faster you move the more head-like your front is likely to become. For a free-swimming animal, it helps to have your senses stacked up-front, in a head, where you first encounter novelty in your environment. Of course, it also helps if you have a brain, to process all that information coming in from your head-mounted sense organs. (Roberts, 2015, p. 41)

From ocean to land, fins gave way to legs, which eventually, at least in Primates, evolved into arms as well as legs. The form of the human body, including the possession of a central nervous system, probably has its roots in the capacity for motion (Roberts, 2015, p. 41).

Contrary, and excluding robots and robotics from our enquiry, we can conceive of Technology hardware as being something stationary, or unmoving. It is probably appropriate to consider Alan Turing’s universal machine as the starting point for Computers. It follows then, that the evolution of computing spans just over eight decades, a tiny footprint compared to the chordates five hundred and forty million years. In 1946, exactly ten years after the



development of Turing's universal machine, the first digital stored-programme computers were introduced. And true to function, these technologies did not possess a front or a head. These early systems were simple computing devices capable of calculating mathematical equations and had applications in code breaking, rudimentary mathematics and statistical analysis. The modern computer, with a mouse and Graphical user interface (GUI) only arrived in 1964. We could liken the GUI of a modern computer to a front but, using deductive reasoning, it is unlikely that this 'front' was designed because it had any inherent value. Rather, it is far more likely to be a response to the fact that the users who interact with them have their senses stacked up front.

It stands to reason that if the computer's features for interaction are stacked up front, then the processing features would be located close behind in much the same manner that a human brain sits behind the human 'front'. A computer does not eat therefore it has no need for a mouth or stomach, or limbs that would enable it to go forth and source food. Instead, computers can be switched on or off (by humans) depending on whether they have a viable battery or other power source. And, as a computer has no need for a body or limbs, a box-like form is quite sufficient, optimal even.

Whilst the nervous system in humans and their ancestors evolved from a diffused to a centralised system, modern technology has features of both. Unlike biological evolution, Technological evolution does not necessarily need to negotiate its form based on its ancestry. If a feature loses its value over time, it can simply be excluded from future design. Likewise, features that are intended to perform similar functions can co-exist. Networks and cloud computing are examples of centralized computing systems whilst block chain is an example of a diffuse one. For the purpose of being succinct, the next section, sensing, will focus on centralized processes only.

### 4.2 SENSING

It can be said that the senses (individual level) and culture (collective level) are the fundamental measures of experience among humans. In order to think about sensing in a way that is compatible for both Humans and Technology, let us begin by developing a common frame of reference.

To sense something that is external to the sensor but within the same environment is to experience (observe) and qualify that thing using a sensory instrument and classifier. Humans

have several sensory instruments which are often referred to as the five senses: sight, hearing, smell, taste and touch. These instruments automatically gather and send information to the brain where it is classified, or, given meaning. Several technologies have been developed to afford Technology similar opportunities. However, unlike humans, the sensory apparatus of technology can be remote and spread out across geographical space. This geographical reach, at least on earth, is, theoretically speaking, limitless. Cameras, microphones and a range of devices that are capable of measuring variables in the physical world can be harnessed to gather and send data to an information repository where it will, if programmed to do so, be classified. This affords technology a significant advantage over humans.

Other than the local and global distinction between the range in sensing that humans and technology can experience respectively, there are a few other key differences. For example, humans can experience pleasure, or conversely displeasure, whilst technology cannot experience either.

Whilst sensing is, fundamentally, also a form of communication, the key differences between it and communicating is that sensing is the passive retrieval of data in an environment whereas communication is something co-operative. In sensing, the thing that is sensed is not necessarily aware of the sensor. A man observes a sunrise, overhears birds in song and feels the cold and pain of a blustery rainstorm. Technology observes IP addresses and internet activity, a store view or a street view, the temperature/humidity of the air.

### 4.3 COMMUNICATING

Communication is the *'sharing of information with others by speaking, writing, moving your body, or using other signals'*. Cooperation is *'the act of working together with someone or doing what they ask you'*. Collaboration is *'the situation of two or more people working together to create or achieve the same thing'*. (Cambridge Dictionary)

Communication is the essential cornerstone of cooperative and collaborative action, which in turn are essential for human tribes (society) to survive and thrive. Spoken language is the primary vehicle for human communication whilst IT infrastructures support communications across Technology. Human language is an instinct (Pinker, 1994) with a tribal character that develops as naturally in childhood as the body grows.

the linguist Derek Bickerton has presented evidence that in many cases a pidgin can be transmuted into a full complex language in one fell swoop: all it takes is for a group of children to be exposed to the pidgin at the age when

they acquire their mother tongue. That happened, Bickerton has argued, when children were isolated from their parents and were tended collectively by a worker who spoke to them in the pidgin. Not content to reproduce the fragmentary word strings, the children injected grammatical complexity where none existed before, resulting in a brand-new, richly expressive language. The language that results when children make a pidgin their native tongue is called a creole. (Pinker, 1994, p. 33)

Computers cannot create their own languages. Quite unlike humans, they do not possess a mental blueprint to do so. However, in the same way that humans collaborate more effectively when they share a common language, computing also requires a common grammar for same. Far more finicky than human languages however, computing languages do enable programmes and programmers to instruct computers on what tasks they should execute and when. The apparatus that facilitates this process is a network.

One of the key differences between the nature of human communication and digital communication is the open-to-interpretation quality of human language. Language is far more than words, grammar and syntax. It is a cognitive process and a way of thinking. Humans discover new knowledge through the act of speaking and writing. On the other hand, digital communication is nothing more than a form of transference. In other words, nothing can be learned directly through the activity of communication itself.

There are many other interesting facets to human communication that find no equivalent in Technology. One example is the function of language as an instrument for bonding (Pinker, 1994) which is a point worth noting as it lends itself to an understanding about the instinctive nature of human language as an instrument for survival and prosperity.

Human-machine interfacing is the method in which humans and machines actively communicate, co-operate and collaborate with one another. In the early years of information technology, and until quite recently, communication between humans and technology was characterised by a unidirectional instructional format. The direction of this communication was from human to technology. An example of this traditional format is a person using a text editor, such as Microsoft Word, to write a research paper. The human presses a key on a keyboard and the software system adds the corresponding character to the Word document. Other examples include a person switching on or off a printer, a TV, a camera, pressing the play button, the pause button, and deleting or forwarding selected media.

In more recent years, communication between humans and technology has evolved considerably. Many technologies are now programmed to observe, read, assist and/or instruct humans. Their role has shifted from one that is passive to one that can engage in passive and active tasks. Technologies are often aware of their user's interests either as the result of direct user input, or, by observation and recording of their user's interactions with a variety of media. This enables appropriately designed technologies to follow and/or profile their users, mainly for advertising, but for other purposes too. For example, Google Maps and other transport apps can assist users in planning journeys whilst applications that employ recommender systems (Amazon, Netflix) can assist users with purchases, viewing and other selection services.

### INTERIM SUMMARY

Thus far, we have populated three of the four quadrants in the canvas, Forming, Sensing and Communicating, respectively.

Table 6 illustrates a summary of the results of the comparative analysis to date. It demonstrates that one of Technology's advantages resides in the global reach and ubiquitous nature of its sensing capacities. This presents very real opportunities, now and in the future, for humans to exploit technology in the areas of digital surveillance.

**TABLE 6: SUMMARY OF HUMAN AND TECHNOLOGY COMPARATIVE ANALYSIS**

	<b>Humans</b>	<b>Technology</b>
<i>Forming</i>		
<i>Designed</i>	for motion	for human interaction
<i>messaging</i>	Central Nervous System (CNS)	Can be centralised and or distributed
<i>Sensing</i>		
<i>Environment</i>	Local	Global
<i>Information type</i>	Biological readers & signals	Digital readers & signals
<i>Communicating</i>		
<i>Expression mode</i>	Written & spoken language	Transferred via a network
<i>Purpose</i>	Motivated (surviving, thriving)	Programmes (execution)

## 4.4 LEARNING

Four theories of learning will be discussed in the following paragraphs, one that apply to humans, one that applies to Technology, and, two that apply to both humans and Technology. As before, the objective here is to compare and contrast humans and technology with a view to developing a stronger capacity for humans to anticipate the role of technology in the future.

This conclusion will focus on learning theories as opposed to teaching theories because what we are concerned with here is the nature of learning. In the analysis of chapter 3, educational discourses arising in the embeddedness group were prioritised because of their appropriateness for application in a group-based learning setting. This conclusion is concerned with how individuals learn in general therefore it is not necessary to restrict our choices to discourses falling solely within any group. In the case of technology-based learning (what constitutes as a learning-machine cluster in Davis and Frances resource) all clusters are, by their very nature, eco-complexity based. In other words, they apply to ‘more than human’ matters.

The learning theories that have been selected for review are as follows, *Radical constructivism*, *Machine Learning*, *1<sup>st</sup> order Cybernetics* and *2<sup>nd</sup> order Cybernetics*. Table 12 sets out the discourses, indicating their relative group(s) and clusters. *Radical constructivism* was selected because it is a theory that focuses on individual sense-making and knowing. The theory is often applied in teaching discourses that leverage problem-based or inquiry-based learning. *Radical constructivism* is also part of the long constructivist tradition which includes the work of Jean Piaget and Jerome Bruner. *Machine learning* was selected from a handful of options in the learning machine cluster because of the many parallels that exist between smart machine processes and human cognitive processes. *1<sup>st</sup> order and 2<sup>nd</sup> order cybernetics* were selected because they can be applied to organic and inorganic systems alike. Cybernetic theory is also the subject that inspired this research paper, expressed in Pia Tikka’s *Obsession* installation (2005). Subjects such as cognitive science and artificial intelligence both draw on the principles of this theory.

**TABLE 7: SELECTED LEARNING THEORIES**

<b>Learning Discourse</b>	<b>Group(s)</b>	<b>Minor Cluster(s)</b>
Radical Constructivism	Embodiment	Non-Trivial constructivism
Machine Learning	Eco-complexity	Learning machines
1 <sup>st</sup> Order Cybernetics	Eco-complexity	Cybernetic systems, learning machines, emergent
2 <sup>nd</sup> Order Cybernetics	Eco-complexity	Cybernetic systems

#### 4.4.1 RADICAL CONSTRUCTIVISM

Knowledge must be discovered through a cognitive process, but ‘cognition does not permit the discovery of an objective ontological reality’ (Von Glasersfeld, 1995) (Millwood, 2013). As discussed in the sensing and communicating section of our comparison model in chapter 2, technology has the capacity to transfer information from its origin and reproduce it elsewhere with almost no loss of fidelity. As a process of reproduction is not a process that produces knowledge it must reside outside a definition of learning.

*Radical Constructivism* also holds that it is the organization of information or the process of organising information that cognition plays a role in (Von Glasersfeld, 1995) (Millwood, 2013). In information technology, information is usually organised in a database of which there are two forms, relational and non-relational. In a relational database, the traditional and more prevalent form, structured data is stored in tables and organized according to parameters and relationships with other parameters. The structuring (or organizing) of the parameters and relationships in a relational database are undertaken by an agent outside the technology, i.e. by a database developer. According to *radical constructivism* then, the developer (a human or group of humans) is the cognitive force.

In a non-relational database unstructured data can be stored according to several configurations, for example, in a key-value pair arrangement. In this instance the programme organises the data itself and the algorithm can be said to behave as the cognitive force. However, the algorithm that undertakes the organizing activity is programmed by an agent outside the technology, again by a human or group of humans. It is not beyond conception that technology could independently select the most appropriate algorithm for a given task, far from it, however, the technology would have to be programmed by an agent outside itself to take on

the task of algorithm selection. In this way, we might say that humans are the cognitive process that organise information for Technology.

Alas, *radical constructivism* is intended to describe an aspect of human intelligence, not machine intelligence and taking from another perspective, one might infer that humans require cognitive powers for the very reason that they cannot discover objective ontological reality. And, if humans disappeared tomorrow, putting aside the question who would power up the technology, what use would it have for cognitive powers that organise information? It can be argued that the purpose of the front that characterises the form of technology (a screen) has its equal in the intelligence that characterises the learning nature of technology. In other words, it only exists to serve human needs.

could a machine think? My own view is that only a machine could think, and indeed only very special kinds of machines, namely brains and machines that had the same causal powers as brains. And that is the main reason strong AI has had little to tell us about thinking, since it has nothing to tell us about machines. By its own definition, it is about programs, and programs are not machines. (Searle, 1980)

Without entering a discussion to define what thinking is, Searle makes an excellent point about what it is not.

### 4.4.2 MACHINE LEARNING

Machine learning does not conceive of learning in terms of ‘thinking’. Instead, it equates it to operational activity, something that computers do very well. Machine learning involves structuring and programming raw material (data) for a variety of performance-based tasks such as sorting and classification, probabilistic modelling and AI. There are three major paradigms in machine learning as illustrated in Table 8 below.

**TABLE 8: MACHINE LEARNING PARADIGMS**

Paradigm	Name	Example	Character
1	Supervised learning	Predictive	Signals
2	Reinforcement learning	Approximate dynamic programming	Statistics

3	Unsupervised Learning	Clustering and other algorithms that seek patterns	Patterns
---	-----------------------	--	----------

It is possible to find an expression for each of these three machine learning paradigms in the human brain. The theory is that our first ancestors who could swim were not unlike the ancient *Haikouella* or modern-day lancelet (Roberts, 2015). Both creatures possess(ed) a tiny brain with three distinct chambers. In fish, the brainstem (hind brain and mid brain) is the biggest part of the brain. As we move from fish to amphibians to reptiles and onto mammals respectively, the relative brain size between the brainstem and the cerebral hemispheres switches so that the cerebral hemisphere becomes increasingly large relative to the brainstem. Mammals have also developed another structure, the neo-cortex. Without wanting to oversimplify the way the brain operates, each of these brain areas are involved in specialised tasks.

The hind brain and the mid brain are involved in homeostasis, the primitive cerebral hemisphere (limbic cortex) is involved in behaviour whilst the neo-cortex is concerned with sensory and motor activities (of being in the world). To model homeostasis, one might employ signal processing, to model behaviour one might employ a statistical model, whilst, to model the senses, one might employ a pattern or clustering algorithm. Table 9 illustrates an equivalency table between machine learning and brain function operations.

**TABLE 9: EQUIVALENT OPERATIONS BETWEEN BRAINS AND MACHINE LEARNING PARADIGMS**

Brain Structure	Machine learning Paradigm	Character
Hind Brain	Supervised learning	Signals
Limbic cortex	Reinforcement learning	Statistics
Neo-cortex	Unsupervised Learning	Patterns

Whilst these parallels exist, it is unquestionable that computing technologies significantly outperform humans in terms of their predictive power and the speed at which they can arrive at an answer or solution. On the other hand, one of many things that appears to distinguish humans from technology is that humans learn and evolve in a self-perpetuating manner which allows them to act in seemingly spontaneously ways. Put another way, humans are alive and as Glasersfeld (1997) states ‘The universe does not determine what we do, but only what we (humans) cannot do’. Imagination is a valued human ability however one might ask if this



ability is born out of man's inability to reach models of perfection? And if so, does technology offer a superior alternative?

#### 4.4.3 CYBERNETICS – AUGMENTING LIFE WITH THE POWER OF TECHNOLOGY

Cybernetics was defined in the late 1940's by Norbert Wiener. As with many educational theories, cybernetics does not possess a precise definition or description as it finds expression in many disciplines, however a few of note are as follows:

The original definition is that cybernetics is "*the scientific study of control and communication in the animal and the machine.*" (Wiener, 1948)

A less formal description arising from the field of philosophy is that "*cybernetics is the art of creating equilibrium in a world of possibilities and constraints.*" (Von Glasersfeld, 1997, p. 137)

A more formal description arising from the field of biology is that "*cybernetics is the study of systems and processes that interact with themselves and produce themselves from themselves*" (L. Kauffman, not formally published, but widely circulated) (Letelier, et al., 2011).

In all cases we can perceive that cybernetics is about systems. Feedback is critical to the theory of cybernetics and is expressed in Wiener's original definition that emphasises control and communication.

Comparing Von Glasersfeld's and Kaufmann's description, a system that 'seeks balance within an envelope of what is possible and what is impossible' and one that is self-perpetuating are not the same thing. The former focuses on the conditions that makes self-perpetuation possible whereas the latter focuses on the activity of self-perpetuation and assumes the conditions that make it so. Von Glasersfeld's definition focuses on the concept of requisite variation and is consistent with Universal Darwinism where the capacity for life is determined by meeting certain thresholds, or conditions, for survival.

Second order cybernetics was established by engineer and cyberneticist, Heinz von Foerster, when he introduced the concept of the 'observing agent' into the cybernetic theory.

Pia Tikka's enactive cinema, for which this research is inspired, was originally connected to the idea of 1<sup>st</sup> order cybernetic control, that is, until it became apparent that it exhibited traits of self-organization (Tikka, 2008). The system feeds on the emotion of the viewer, the spectator feeds on the cinematics whilst the cinematics feeds on the system's adaptive capacity. From this perspective 'Obsession' can be viewed as an intimate example of human-machine symbiosis, which has the power to shape the viewer and the author as equals in the production of a performance.

Heinz von Foerster set up the Biological Computing Laboratory (BCL) at the University of Illinois in Urbana Champaign in the late 1950's. The BCL influenced important ideas about self-organization. It was also the BCL who first described the term autopoiesis which is "the property of a living system that allows it to maintain and renew itself by regulating its composition and conserving its boundaries (Letelier, et al., 2011). Connected by the description for autopoiesis, Kaufmann's definition of cybernetics as a self-perpetuating system is realised within the 2<sup>nd</sup> order of cybernetic theory.

When we evaluate humans and technology against a learning theory such as radical constructivism or machine learning, even without going into a lot of detail, it becomes quite apparent what the differences are between human and machine experience, and by extension, their respective 'cognitive' capabilities. Humans organise, perceive and imagine. Technology replicates, calculates and predicts. Cybernetics, on the other hand, illustrates the capacity for a symbiotic relationship.

We can now conclude our framework for the comparative analysis between humans and technology (Table 10).

**TABLE 10: SUMMARY OF HUMAN AND TECHNOLOGY COMPARATIVE ANALYSIS**

	<b>Humans</b>	<b>Technology</b>
<i>Forming</i>		
<i>Designed</i>	for motion	for human interaction
<i>messaging</i>	Central Nervous System (CNS)	Can be centralised and or distributed
<i>Sensing</i>		
<i>Environment</i>	Local	Global
<i>Information type</i>	Biological readers & signals	Digital readers & signals
<i>Communicating</i>		
<i>Expression mode</i>	Written & spoken language	Transference (via a network)
<i>Purpose</i>	Motivated (surviving, thriving)	Programmed (execution)
<i>Learning</i>		
<i>Data</i>	Knowledge	Information
<i>The Cognizing Agent</i>	Self	Human
<i>Strength</i>	Capacity to Organise Perceive & Create	Reproduction of objective ontological reality, Calculation, (and by extension) Prediction

## 5 CONCLUSIONS & FUTURE WORK

### 5.1 TEACHING THEORIES FOR THE PROPOSED WORKSHOP

Drawing on the analysis to select appropriate teaching discourses in Chapter 3, Table 11 sets out the recommended teaching theory for each respective stage of the workshop.

**TABLE 11: SEQUENCE, NAME AND PROPOSED TEACHING THEORY FOR EACH STAGE IN THE WORKSHOP**

Sequence	Name	Purpose	Appropriate Teaching Theory
1	Exploration	Forming & Foundation	Design thinking/ Critical theory
2	Design	Construct what is Possible	Design thinking
3	Sense-Making	Construe what is Probable	Critical theory

#### 5.1.1 LEARNING AIDS AND WORKSHOP STRUCTURE

It is recommended that variation theory methods be utilized to develop and structure the content for the workshop. As stated earlier, variation theory employs several principles from cognitive science to reduce cognitive load and increase attention among learners. Suitable methods could include:

- Stories that paint high level overviews,
- appropriate chunking/grouping of content (harnessed in the Human and Technology Canvas of chapter 4),
- making use of affordances and/or employing novelty
- devising immersive learning activities

In chapter 4 this paper set out a framework for the ‘*systematic comparison of human and machine intelligence*’. This framework, or canvas as it was referred to, could be used in the proposed workshop to facilitate an understanding of the differences between people and technology. The layout of the canvas takes advantage of the chunking method, and, facilitating a session to populate the canvas could result in immersive learning.

As stated earlier, developing learning aids for the proposed workshop is beyond the scope of this paper and is noted as an objective for future work.

### 5.1.2 WORKSHOP STAGES

#### STAGE 1 DELIVERY

Stage one is designed to provide participants with an understanding of the subjects of the workshop. Essentially, the purpose is to create a common language among the participants whilst introducing information on the primary objects (Humans and Technology) and the selected topic (Food consumption). An outline of the artefacts that correspond to the topic are listed in Table 12 below whilst some corresponding content is available in Appendix 1.

**TABLE 12: SUBJECTS AND TECHNOLOGIES THAT REQUIRE AN INTRODUCTION**

	Artefacts
1	Self-driving Cars
2	Health Apps, Smart Fridges
3	Smart screens, Smart glasses, Smart windscreens

Brainstorming and the construction of information models from classification exercises are methods from the *Design thinking* toolbox that could be leveraged here to meet the objectives of this stage of the workshop.

#### STAGE 2 DELIVERY

During the Design stage, participants will explore the digital landscape of the future in an indirect manner. Rather than thinking about the people though they will focus on the tools they might use instead. We can think about these tools as ‘possible’ cultural artefacts, and a means to infer something about a ‘future’ society.

To achieve this, participants will be asked to construct a mock-up of two dashboards, one for ‘Eating in’ and another for ‘Eating out’. The quickest way to paint a picture of the proposed format is to imagine teams of 2-4 people working together to create mock-ups of user interfaces (UI) for ‘future’ food apps. A UI templating system should be sourced to support this activity. Teams are also welcome to draw their own templates for inclusion in their models and should be encouraged to do so when they feel the generalised content is insufficient to capture their ideas.

The aim of this stage is to encourage workshop participants to think about to what extent man and machine will make decisions in relation to a user's food consumption in the future. Will the applications of tomorrow merely serve up raw data such as restaurant names, cuisines, ratings and travel distances in the manner that they currently do today, or, will the applications eliminate certain options and instead rely on factors such as blood sugar levels, food allergies, diet targets, availability, conservation etc.? The range of templating options should provide the participants with the capacity to build models that represent either a 'passive-machine, active-human' future or a 'passive-human, active-machine' future. It should also be possible to build models somewhere in between these polar possibilities. The range of hardware and digital applications that the mock-ups can draw on are illustrated in Table 13 below.

Whilst it is anticipated that most teams will design either a mobile interface or smart glass for the 'Eating In' event and a windscreen sized interface for the 'Eating Out' event, teams are free to choose whichever hardware and corresponding screen size they deem most suitable.

**TABLE 13: EXAMPLES OF HARDWARE AND DIGITAL APPLICATIONS FOR STAGE 2 OF THE WORKSHOP**

Technology	Category	Function
<b>Model 1: Who decides what food is in your fridge?</b>		
Biometrics	Ubiquitous Computing	Monitoring Technology
Smart Fridge	Ubiquitous Computing	Monitoring Technology
AR Glasses	Extended Reality	Expressive Technology
<b>Model 2: Who decides when and where you eat?</b>		
Biometrics	Ubiquitous Computing	Monitoring Technology
Self-Drive Car	Ubiquitous Computing	Automation
Smart Screen	Extended Reality	Expressive Technology
<b>Model 3: Surveillance &amp; Personalization</b>		
Biometrics	Ubiquitous Computing	Monitoring Technology
AR Glasses	Extended Reality	Technology
Surveillance Capitalism	Surveillance Capitalism	Profiling & Targeting
Augmented Advertising		Experience

### STAGE 3 DELIVERY

As per our analysis in chapter 2 of this paper, it is recommended that methods from the Critical Theory toolbox be utilized to structure stage 3 of the workshop. Table 14 lists a few active learning techniques that are suitable for critical theory.

**TABLE 14: LIST OF ACTIVE LEARNING TECHNIQUES THAT ARE APPROPRIATE FOR CRITICAL THEORY**

Method	Duration
Group Discussion	< 1 hour
Case Studies	<1 hour
Think-pair share	<1 hour
Short written exercise	< 1 hour
Debate	> 1 hour
Learn by Teaching	> 1 hour

Future Narratives could be constructed to present ‘plausible’ imaginary futures. These future narratives should be crafted so that the stories are accessible by a public audience (of non-experts), hence providing an opportunity for examination and reflection of the themes contained therein. The method in which the participants examine or reflect on the future narratives would be determined by the group size, the available time and the opportunities afforded to the group by the learning space.

Using future narratives as if they were case studies and employing them in the context of either a group discussion or think-pair-share exercise would be an appropriate format for Stage three of the workshop. The purpose of this stage is to focus the participants on what is likely or feasible in the future based on broader societal and economic forces. This is also the stage in the workshop when we want to encourage participants to think about how man himself might change and evolve as a response to these technological changes, initially in a psychological capacity, but possibly in a physiological capacity too. Given the title of our workshop, there are several subjects that can be used to devise suitable future narratives as follows:

- Food Inventories /Menu Options /Cuisine Options
- Altered and new job roles in the food industry
- Advertising practices

- Farming practices, i.e. choice of crops and livestock

It is intended that any future work relating to the testing and evaluation of the workshop will involve the production of a handful of future narratives. Until then, or alternatively, educators may wish to employ some of the methods from the Design Thinking discourse to facilitate the construction of their own plausible future narratives. Table 15 sets out some popular design methods that can facilitate the construction of plausible narratives.

**TABLE 15: DESIGN THINKING METHODS SUITABLE FOR USE IN THE CONSTRUCTION OF FUTURE NARRATIVES**

No.	Suitable Methods	Time Required
1	Brainstorming	<1 Hour
2	Storyboarding	>1 Hour
3	Personas	<1 Hour

Following the undertaking of the three stages set out above, exploring, designing and sense-making respectively, an evaluation method will need to be implemented to test the quality of the design.

## 5.2 FUTURE WORK

This paper sets out a workshop specification without supplying the recommended learning tools therefore proposed future work would consist of developing the necessary tool kits to allow for greater accessibility to the learning experience. The three tool kits that are required are as follows:

- Content and activities for stage one of the proposed workshop,
- A UI templating kit for stage two of the proposed workshop,
- Several case studies (future narratives) for stage three of the workshop

Providing off the shelf tool kits would allow practitioners with and without design skills to take advantage of the workshop's value proposition.



Any future work will also include product testing including the development of a framework for testing and evaluating the workshop.

### 5.3 FINAL NOTE

To arrest the spread of COVID19 in Ireland, universities, schools, offices, restaurants, shops and bars all began closing their doors in March 2020. This research was originally intended to design and test a workshop. Following lockdown, the research shifted its intentions away from the testing of a workshop to the specification of a workshop. This shift resulted in several redundancies in the work undertaken up to that date, but also created several new opportunities, the primary one being a mandatory deep dive into the sphere of educational theories.

Learning is a fundamental human activity, not an isolated discipline of study. For most of its history, learning theory has been a contested scientific field with many scientific disciplines contributing to the field albeit, with conflicting views (Millwood, 2013). The effect of this has been the development of a complex and confusing landscape that presents challenges for those wishing to navigate it. Brent Davis and Krista Francis have sought to bring order and transparency to this landscape with their online survey. Their hope is that the map will contribute to ‘teaching practices and research emphases that are infused with nuanced and defensible principles of learning’ (Davis & Francis, 2020). This research paper demonstrates the potential of the map as a tool for rapid selection of appropriate teaching theories. It did this when it generated six viable teaching theories for a proposed workshop, given certain constraints. The final shortlist of teaching theories was not anticipated in advance. On the contrary, the shortlist was surprising. It is likely that without undertaking the analysis using the online map, the workshop would have opted to model the learning experience using less appropriate teaching methods.

This paper takes a first step to design a framework (human & technology comparison canvas) that would allow a general audience to develop an understanding of the nature of technology. Whilst the value of the canvas as a learning tool is untested, the production of same was of immense value to the author. Hence, if it proves to be of little value in the learning space, then devising a learning method to produce a similar framework could be a viable alternative. There are several other learning tools that are essential for the proper production of the proposed workshop, as outlined above in the ‘future work’ section.

## Chapter 5: Conclusions & Future Work

This project was motivated by the assumption that the general public are not well informed about the nature of the technologies that are shaping their societies (Zuboff, 2019). This project assumes that the rate at which technology is evolving outstrips the rate at which the mainstream educational channels can proliferate knowledge on the topics and proposes to position this capacity for knowledge building in the public domain. Free from the confines of a bureaucratic institution, and with an information base that can evolve and adapt more readily, this paper hypothesises that it may be possible to develop a wider culture for understanding and anticipating change using a flexible learning model that is delivered at the civic level.

Finally, the proposed workshop is compatible with many abilities that are distinctly human; The capacity to organize, and, the ability to converse and create.

## WORKS CITED

Boys, J., 2010. *Towards Creating LEarning Spaces*. Hoboken: Taylor & Francis.

Davis, B. & Francis, K., 2020. *Discourses in Learning in Education*. [Online]

Available at: <http://learningdiscourses.com>

[Accessed April 2020].

Engeström, Y. & Sannino, A., 2010. Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), pp. 1-3.

Fort, T., 2004. *Tick tock, its time to eat Tom Fort on a study of how biological rhythms make animals eat, sleep and procreate*. [Online]

[Accessed 2020].

Gibson, 2020. *Affordance Theory (Gibson)*. [Online]

Available at: <https://www.learning-theories.com/affordance-theory-gibson.html>

[Accessed May 2020].

Greengard, S., 2019. *Virtual Reality*. s.l.:The MIT Press.

Letelier, J., Cardenas, M. & Cornish-Bowden, A., 2011. From L'Homme Machine to metabolic closure: Steps towards understanding life. *Journal of Theoretical Biology*, Volume 286, pp. 100-113.

Liedtka, J., Azer, D. & Salzman, R., 2017. *Design Thinking for the Greater Good: Innovation in the Social Sector*. s.l.:Columbia University Press.

Millwood, R., 2013. *richardmillwood.net*. [Online]

Available at: <http://blog.richardmillwood.net/>

[Accessed 1 May 2020].

Orgill, M., 2012. *Variation Theory*, Boston: Springer.

Papert, S., 1993. *The Childre's Machine*. s.l.:Basic Books.

Pinker, S., 1994. *The Language Instinct*. London: Penguin Books.

Roberts, A., 2015. *The Incredible Unlikeliness of Being*. 2nd ed. London: Quercus Publishing Ltd.

## Works Cited

Royea, D. A. & Nicol, C., 2019. Pre-service teachers' experiences of learning study: learning with and using variation theory. *Educational Action Research*, 27(4).

Searle, J., 1980. Mind, brains and programs. *Behavioral and Brain Sciences*, 3(3), pp. 417-424.

Talja, S., Tuominen, K. & Savolainen, R., 2003. "Isms" in information science: onstructivism, collectivism and constructionism. *Journal of Documentation*, 61(1), p. 85.

Tikka, P., 2008. *Enactive Cinema—Simulatorium Eisensteinense*, Helsinki: University of Art and Design.

Von Glasersfeld, E., 1995. *Radical Constructivism: A Way of Knowing and Learning*. s.l.:Taylor & Francis Group.

Von Glasersfeld, E., 1997. a Cybernetician before Cybernetics\*. *Systems Research and Behavioral Science*, 14(2), p. 137.

Wiener, N., 1948. *Cybernetics: Or Control and Communication in the Animal and the Machine*. MIT Press.

Zuboff, S., 2019. *The Age of Surveillance Capitalism*. s.l.:Public Affairs.

## BIBLIOGRAPHY

Anon., n.d. [Online]

Available at: <http://www.enactivecinema.net>

[Accessed 03 May 2020].

Ascensia Diabetes Care, 2020. *contournextone.ie/home*. [Online]

Available at: <http://www.contournextone.ie>

[Accessed 2 May 2020].

Bammidi, D. P., n.d. *Qualitative Content Analysis: Why is it Still a Path Less Taken?*. s.l., Qualitative Social Research.

Boys, J., 2010. *Towards Creating LEarning Spaces*. Hoboken: Taylor & Francis.

Davis, B. & Francis, K., 2020. *Discourses in Learning in Education*. [Online]

Available at: <http://learningdiscourses.com>

[Accessed April 2020].

Eat Right Now , 2020. *Heal Your Relationship With Food*. [Online]

Available at: <https://goeatrightnow.com/>

[Accessed 2 May 2020].

Engeström, Y. & Sannino, A., 2010. Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review*, 5(1), pp. 1-3.

Fort, T., 2004. *Tick tock, its time to eat Tom Fort on a study of how biological rhythms make animals eat, sleep and procreate*. [Online]

[Accessed 2020].

Gibson, 2020. *Affordance Theory (Gibson)*. [Online]

Available at: <https://www.learning-theories.com/affordance-theory-gibson.html>

[Accessed May 2020].

Greengard, S., 2019. *Virtual Reality*. s.l.:The MIT Press.

Holzmann, S., Hauner, H. & Holzapfel, C., 2017. *Nutrition Apps: Quality And Limitations*. [Online]

Available at: <https://www.ernaehrungs-umschau.de/english-articles/14-06-2017-nutrition-apps-quality-and-limitations>

[Accessed 29 April 2020].

## Bibliography

Letelier, J., Cardenas, M. & Cornish-Bowden, A., 2011. From L'Homme Machine to metabolic closure: Steps towards understanding life. *Journal of Theoretical Biology*, Volume 286, pp. 100-113.

Liedtka, J., Azer, D. & Salzman, R., 2017. *Design Thinking for the Greater Good: Innovation in the Social Sector*. s.l.:Columbia University Press.

LLC, Sidewalk Labs, 2019. *The Urban Innovations*, s.l.: s.n.,

Millwood, R., 2013. *richardmillwood.net*. [Online]

Available at: <http://blog.richardmillwood.net/>

[Accessed 1 May 2020].

Myfitnesspal, 2020. [Online]

Available at: <https://www.myfitnesspal.com/>

[Accessed April 2020].

MyNetDiary, 2020. *Free Calorie Counter And Diet Assistant*. [Online]

Available at: <https://www.mynetdiary.com>

[Accessed April 2020].

Nemes, A. & Berariu, C., n.d. PERSONIFICATION - A DOUBLE SIDED PHENOMENON. Volume 5, pp. 22-27.

Orgill, M., 2012. *Variation Theory*, Boston: Springer.

Papert, S., 1993. *The Childre's Machine*. s.l.:Basic Books.

Pinker, S., 1994. *The Language Instinct*. London: Penguin Books.

Roberts, A., 2015. *The Incredible Unlikeliness of Being*. 2nd ed. London: Quercus Publishing Ltd.

Royea, D. A. & Nicol, C., 2019. Pre-service teachers' experiences of learning study: learning with and using variation theory. *Educational Action Research*, 27(4).

Samsung, 2020. *Samsung Health*. [Online]

Available at: <https://www.samsung.com/global/galaxy/apps/samsung-health/>

[Accessed April 2020].

Samsung, 2020. *Step Into The Smart Home Of The Future L Samsung*. s.l., s.n.

## Bibliography

Searle, J., 1980. Mind, brains and programs. *Behavioral and Brain Sciences*, 3(3), pp. 417-424.

Talja, S., Tuominen, K. & Savolainen, R., 2003. "Isms" in information science: onstructivism, collectivism and constructionism. *Journal of Documentation*, 61(1), p. 85.

Tikka, P., 2008. *Enactive Cinema—Simulatorium Eisensteinense*, Helsinki: University of Art and Design.

Von Glasersfeld, E., 1995. *Radical Constructivism: A Way of Knowing and Learning*. s.l.:Taylor & Francis Group.

Von Glasersfeld, E., 1997. a Cybernetician before Cybernetics\*. *Systems Research and Behavioral Science*, 14(2), p. 137.

Wiener, N., 1948. *Cybernetics: Or Control and Communication in the Animal and the Machine*. MIT Press.

Zuboff, S., 2019. *The Age of Surveillance Capitalism*. s.l.:Public Affairs.

Zuboff, S., 2019. *The AGE of Surveillance Capitalism*, s.l.: Public Affairs.

## APPENDIX 1: RECOMMENDED CONTENT FOR STAGE 1 OF THE WORKSHOP

### NAVIGATION & SELF-DRIVING VEHICLES

Self-driving vehicles were selected for review for a variety of reasons. On the one hand private motor vehicles are the most popular form of transport in the developed world. Unlike public transport such as a bus or train, they are not just useful for transporting passengers from location A to B, as they provide ample storage for small scale transit of goods such as household shopping and furnishings. Self-driving vehicles were also selected because they satisfy a necessary requirement for vehicle augmentation which we will discuss shortly.

“self-driving vehicles plan their route by accessing maps, traffic data, road and weather conditions, toll information, and more. They continuously refresh all that data throughout the trip, in real time, via an internet connection.”

Almost 65 years (63 to be exact) after the first successfully tested driverless vehicle ‘*on a 120 metre stretch of highway close to Lincoln, Nebraska*’, and, with only fifteen years to go until the planned implementation of self-driving taxis in Toronto, the journey from prototype to a commercially viable mode of transit has been a short one.

DARPA, the US Defence Advanced Research Projects Agency, has been a key player in the move towards self-driving vehicles. They have operated several competitions and offered large prizes for successful engineering in the self-drive domain. In their first challenge in 2004, all entries failed to navigate the 240-kilometre course in the Mojave Desert. One year later, five entries succeeded. The difference between the challenge in 2004 and 2005 is that in 2005, the entrants were supplied with the obstacle data in advance. This is indicative of the value of the role of journey planning for a self-driving vehicular eco-system. Google joined the race in 2009 and were testing their technologies on city streets by 2012. Meanwhile, researchers at MIT were developing their own autonomous technologies.

One MIT spin-off, NuTonomy, began operating autonomous taxis in Singapore in 2016 and in Boston in 2017. Currently, the Toronto branch of Sidewalk Labs are designing a mobility infrastructure that will support (or depend on) large fleets of autonomous vehicles.



## Appendix 1: Content for Stage 1

Sidewalk Labs are basing their master planning on 10 self-driving principles that span three domains, technology, design and policy. These principles predict, among other things, that:

1. *Autonomous vehicles will be commercially feasible in the next ten years.* (Principle 1)
2. *Ride-hail and delivery services will continue to displace vehicle ownership and traditional retail patterns* (Principle 7), but
3. *Personal car ownership will persist* (Principle 8).

Self-driving cars provide a necessary condition for turning vehicle windscreens into detailed dashboards for human-computer interfacing. Whilst smart windscreens are not essential, i.e. passengers could just as easily continue to use their smart phone or opt instead to use a smart glass (assuming they are available), where a windscreen may prove more attractive is its comparatively large size.

Meanwhile, in the world of manually operated vehicles, windscreen dashboards are currently being designed to deliver information that does not distract the driver from the road. Even if this goal is impossible, it is the belief of Sidewalk labs “*that self-driving vehicles will become ubiquitous features of urban life within the next two decades*”, therefore these new windscreen interfaces will be able to respond to the needs of passengers in self-drive vehicles, if not to the needs of passengers in manually operated vehicles.

## SUSTENANCE & HEALTH

### SMART FRIDGES

Smart fridges were selected for review in this phase because the Fridge is the primary store of fresh food produce in the home.

Home appliance companies such as Samsung with their ‘Family hub smart fridge’ and LG with their ‘InstaView ThinQ’ are implementing artificial intelligence features into their products. We will report on just one for the purpose of this paper, The Samsung ‘Family hub smart fridge’.

Image Source: Press Kit at <https://news.samsung.com/us/samsung-reinvents-refrigerator/>



At CES 2020, Samsung design innovation centre's chief design innovation officer, Dr Federico Casalegno, describes the newest model of their AI enabled fridge as a 'personal chef', 'nutritionist' and 'shopping assistant'.

In its original design, the fridge photographed the contents of the fridge to assist a user to make smart produce choices whilst they were shopping. Now, the fridge harnesses a recommender system to recommend to a user what items they should buy using information such as the depletion of food types and the users eating habits as a basis for the recommendations.

The fridge utilizes Samsung's AI enabled home assistant Bixby. Whilst the touchpad permits visual and tactile interaction, the newest upgrade also harnesses speech technology to enable voice interaction. This eliminates the need to 'look' at the screen when carrying out collaborative tasks such as cooking meals with Bot Chef, the fridges built in food prep assistant.

Bot chef can (or will) harness a recommender system to recommend meals and meal plans based on factors such as availability of ingredients, the users eating habits, and even, recent activities such as a trip to the gym.

## HEALTH APPS

Health apps with a focus on nutrition, but not excluding exercise, were selected for review because the author deemed them critical to any discourse involving the future of food consumption. As with many software applications, they have the capacity to be integrated with other hardware and software where synergistic use cases exist.

across the globe, the app stores iTunes (Apple) and Google Play offer roughly 4 million apps, of which about 3% address the topic of "health and fitness [Holzmann, 2016].

## Appendix 1: Content for Stage 1

In 2016 there was circa 120,000 apps that were categorised as ‘health and fitness’ orientated. For the purpose of our workshop design, a handful of applications will be introduced here. The first is a suite of apps called ‘MyNetDiary’ which has been selected because of its excellent reviews. The second is a medical orientated app called ‘Contour Diabetes’. The third app, ‘Eat right now’ is a wellbeing app. The fourth and final app doubles up as a core technology called ‘Samsung Health’ that is harnessed in several third-party apps. Samsung Health has been selected because, in common with the ‘Family Hub Smart Fridge’, it is a Samsung product.

MyNetDiary has two products, their standard calorie counter app, and, a diabetes and diet tracker. According to their Website, MyNetDiary “*has over 800,000 professionally-entered and verified foods with accurate information on servings*”, making them a reliable nutrition partner.

The CONTOUR DIABETES app (IE) by Ascensia Diabetes Care is an app that integrates with “*a CONTOUR connected meter for seamless blood glucose (BG) monitoring. This easy-to-use app can give you a better understanding of how your daily activities affect your BG results to help you manage your diabetes.*” The ‘Contour Diabetes app’ includes several features as follows:

- My Patterns, for identifying trends
- Test Reminders
- Diet, activity and medication recording
- Views

Eat Right Now® have an app of the same name that supports users to conquer food cravings.

## HUMAN-COMPUTER INTERFACES

An introduction to human-computer interfacing is critical because it will demonstrate to the participants the elements and purpose of a visual user interface. In this way, it is preparing them for the prototype construction activities that they will undertake a little later in the next phase of the workshop.

### THE MIXED REALITY LANDSCAPE

The author consulted Chapters 4, 'Extended Reality Gets Real' and Chapter 5 'Virtual Technologies Change Everything' of Samuel Greengard's 'Virtual Reality' as a reference for this subject matter.

Greengard illustrates the '*continuum of physical and virtual objects*' on a scale that ranges from the real environment (in which we are all familiar) to a virtual environment. Along the journey from real to virtual, we encounter two other environments, augmented reality and augmented virtuality (where the virtual world is augmented). When contrasted with physical and virtual reality, part of the nature of augmented reality is that it displays information that is either requested by or personalised for the user. This nature is what makes augmented reality so appropriate for use in food technologies.

### AUGMENTED REALITY

Design, engineering and integration of multiple technologies, from sensory feedback systems and computer programmes to graphical displays and visual overlays is central to the provision of mixed reality experiences.

### SMART SCREENS

After defining what a smart screen is, we will tie this section to the Sidewalk City initiative and demonstrate how the information collected by the Kiosks and sensors can be presented to the people inhabiting the vehicle. We can expect to review potential for:

- Geo-information
- Menus
- Entertainment
- Work

## SMART GLASSES

Smart Glasses are a lot like your smart phone, only they are hands free. Smart glasses will also be a lot like a smart windscreen, only you will probably be stationary. More suitable applications of smart glasses will occur on foot, whether you are at home, or at work. As food is of particular interest to this Workshop, we will explore how smart glasses may integrate with smart fridges.

Heads up displays (HUD's) and smart glasses are the hands-free solution to smart phones. HUD's came into use in the 1970's where they were used in military and commercial aircrafts to project data onto a glass windshield. Today, AR systems are harnessed in many use cases across many sectors.

Pic: Daqri Smart Glasses®,  
Image; ©Daqri



Pic: Tilt Five Smart Glasses,  
Image: ©Tilt Five



Daqri's Smart Glasses®, powered by Daqri Worksense™, provide a suite of features that can be applied in a range of professional industries. For example, tagging or scanning objects for asset maintenance and inspections, and, viewing full scale models of systems and construction data using BIM (Building Information Modelling) 360 docs. Meanwhile, in the gaming sector, Tilt Five's smart glasses offer holographic tabletop gaming.

Smart Glasses can be integrated with countless features and programmes from specific use cases such as navigation to more generic features such as speech recognition, video capture and audio instructions.

## Appendix 1: Content for Stage 1

*AR manufacturers are also exploring how to embed sensors and systems into clothing and other wearables, so that a smartphone or other computing device won't be required to power the AR or MR display* (Greengard, 2019)

There is even talk about AR replacing all screens, from smartphones to TV's, and, that these systems may, eventually, be controlled by the brain. We will review a case study on user-controlled systems when we cover Phase three of the Workshop. For now, we will limit our discussion to smart glass technologies with a case study on Google Glass

## APPENDIX 2

### PIA TIKKA'S OBSESSION AS A CASE STUDY FOR USE IN STAGE 3 OF THE WORKSHOP

OBSESSION BY PIA TIKKA (2005)

Pia Tikka's 'Obsession' has been selected as a case study for the workshop because it relies on a relatively sophisticated form of personalization, and, because it is a cinematic exhibition that is encountered in the public domain. The purpose of introducing this topic to the participants is to invite a discussion about the potential impact of personalised technologies on human psychologies. This case study would be better served if it spans several innovations, possibly commencing in the 1920's with William Marston's lie detector component.

'Obsession' falls into the category of enactive cinema, a type of cinema that was defined by Pia Tikka, the author of 'Obsession' and which can be described as a novel form of interactive cinema where the narrative emerges in response to the viewer's reaction. It can be described as an emotion-simulation dynamical system. Instead of the spectator directly manipulating the narrative, it unfolds as an effect to the spectator's emotional participation.

Table X: An excerpt from Pia Tikka's paper, pg. 268

What intrigued the author of our workshop about Pia Tikka's fascinating work was a simple idea. What would happen to society if man could no longer lie ... to others, and to him/herself? If sensors are inserted into leisure spaces, workplaces and homes; if these sensors are harnessed to collect data and predict our deepest desires and feelings; how would this change our relationships to ourselves and to others? In terms of how one designs enactive cinema, Tikka considers,

IF CURRENTLY		THEN			
$C_i$		$A_t P_t$	$r_i$	$A_x P_x$	$W_i$
HR	EDA	Current property		Follower property	Influence
-	+	10. DOMINANCE	ATTRACTS	11. ACTIVE-AVERSIVE-CONTROL	
-	+	6. POSITIVE	ATTRACTS	6. POSITIVE	
-	+	7. NEGATIVE	ATTRACTS	15. ABRUPTION-SURPRISE	
+	-	8. COMEDY-TENDENCY	REPELS	7. NEGATIVE	
+	-	6. POSITIVE	ATTRACTS	11. ACTIVE-AVERSIVE-CONTROL	
+	-	10. DOMINANCE	ATTRACTS	15. ABRUPTION-SURPRISE	
+	+	10. DOMINANCE	REPELS	12. PASSIVE-ACCEPTING	
+	+	6. POSITIVE	REPELS	11. ACTIVE-AVERSIVE-CONTROL	
+	+	7. NEGATIVE	ATTRACTS	11. ACTIVE-AVERSIVE-CONTROL	
+	+	11. ACTIVE-AVERSIVE-CONTROL	REPELS	12. PASSIVE-ACCEPTING	
+	+	12. PASSIVE-ACCEPTING	REPELS	7. NEGATIVE	
+	+	15. ABRUPTION-SURPRISE	ATTRACTS	11. ACTIVE-AVERSIVE-CONTROL	
-	-	12. PASSIVE-ACCEPTING	ATTRACTS	7. NEGATIVE	
-	-	10. DOMINANCE	REPELS	10. DOMINANCE	
-	-	15. ABRUPTION-SURPRISE	REPELS	15. ABRUPTION-SURPRISE	
-	-	7. NEGATIVE	ATTRACTS	11. ACTIVE-AVERSIVE-CONTROL	
+	+	38. EMBODIED-HIGH-FQ	ATTRACTS	38. EMBODIED-HIGH-FQ	
+	+	39. EMBODIED-MID-FQ	ATTRACTS	39. EMBODIED-MID-FQ	
+	+	40. EMBODIED-DARK-LOW-FQ	ATTRACTS	40. EMBODIED-DARK-LOW-FQ	

Table 1. Emotion-related interpretations of ascending and descending heart rate (HR), and electrodermal activity (EDA).

the authoring of enactive cinema as a modelling process, which involves the following phases: a) constituting a cinema ontospace as a framing of world (dy - namical ontospace); b) cinema montage for generating the functional interaction between the entities of the cinema ontology ('inner' interaction dynamics); and further, c) psychophysiological

## Appendix 2: Pia Tikka's 'Obsession' as a case study

simulation dynamics for tracking the spectator's enactment ('outer' interaction dynamics). (Tikka, 2008)

The 'Obsession' exhibition predicts what a viewer is experiencing based on several physical inputs including the viewer's heartrate (HR) and electro-dermal activity (EDA) along with a number of other sensorimotor inputs.