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Learning outcomes afforded by self-assessed, segmented video–print combinations

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Abstract: Learning affordances of video and print are examined in order to assess the learning outcomes afforded by hybrid video–print learning packages. The affordances discussed for print are: navigability, surveyability and legibility. Those discussed for video are: design for constructive reflection, provision of realistic experiences, presentational attributes, motivational influences and teacher personalisation. The video affordances are examined through a framework of pedagogic design principles and a set of pedagogic roles that video is outstandingly capable of yielding. The paper first discusses the learning outcomes afforded through video alone, then through print alone, and finally through three versions of video–print combinations. One version involves non-segmented video, complemented with print material. In the other two versions the videos are divided into short segments, one version having narration, while the other has only printed commentary. All three versions include self-assessment questions after each segment. The learning outcomes posited by the paper for each of the three video–print-versions are categorised using the Revision of Bloom's Learning Taxonomy. This categorisation can help teachers to assess whether the outcomes they intend for a lesson can be advanced by one of the three versions. This is particularly relevant for teachers who are flipping classrooms or developing massive open online courses (MOOCs).

Subjects: Design & Delivery; Open & Distance Education and eLearning; Study of ODL and eLearning

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Subsequently, as a freelance consultant, he has conducted over 60 workshops and consultancies on educational media design, in 36 countries. He has also produced video/print and AV teacher training materials and trained producers of same in 11 countries. He has published many papers and instructional texts, plus a book, designing video and multimedia for open and flexible learning, Routledge 2006, reprinted 2009.

PUBLIC INTEREST STATEMENT

The learning outcomes posited by the paper for each of three styles of video–print hybrids are categorised using the Revision of Bloom's Learning Taxonomy. Thereby, teachers who intend to show videos and text in class or online can judge which of their intended outcomes can be advanced by which style of video–print combination.

Keywords: self-assessment questions; suggested answers; segmentation; learning affordances; video–print combinations; Revised Bloom's Taxonomy; pedagogic design; video's presentational attributes and teaching functions; video clips and quizzes in flipped classrooms and MOOCs

1. Introduction

The practice of dividing media materials into short segments, enabling self-assessment after each segment, has been around for decades. It was popularised by Skinner's behaviourist "teaching machines" in the 1950's, but has a history back to an 1866 patent of a machine to teach reading (Benjamin, 1988). The UK Open University employed cognitive/constructivist versions of self-assessed segmentation for its printed materials from its beginnings in 1970 and for combinations of video and print since the 1980s.[1]

This paper analyses the learning outcomes that can be achieved through several types of segmented self-assessed materials, including various combinations of video and print.

In the examples below, one produced at the UK Open University (OU Course S325 Biochemistry and Cell Biology, 1985) and another in Vietnam (Koumi, 2008), the printed materials were distributed *on paper*. However, the discussion applies equally to on-screen text, e.g. when video and text are supplied in an eBook, a USB flash drive, a DVD, or online.

The examples illustrate three versions of video–print combinations, all with self-assessment questions: one with preparatory print material for non-segmented video, compared with two styles of segmented video–print packages. One of these segmented styles is video-led (the video narration does the teaching); the other style is print-guided (printed notes interpret the video content). The assessment in all three combinations is *formative*: they all include suggested answers, enabling learners to check and consolidate their knowledge.

The learning outcomes afforded by the three types of video–print combinations will be characterised in terms of Figure 1, the Revision of Bloom's Learning Taxonomy (Krathwohl, 2002). The Revision comprises six cognitive processes, each applying to four knowledge dimensions. Each of the 24 cells identifies a particular kind of learning outcome. This paper will posit which such outcomes can be achieved by type of video–print combination. Thereby, teachers who intend to show videos and text in class or online can judge which of their intended outcomes can be advanced by which type of video-print combination. This is also valuable for teachers who are developing massive open online courses (MOOCs), since a major component of MOOCs are video clips interspersed with printed quizzes.

In preparation for the Revised Taxonomy analysis, the learning outcomes enabled by video–print combinations will first be examined for each medium separately, video first and then print. This examination will be in terms of the research literature and the distinctive learning affordances for each medium.

For this purpose, the term "affordances" requires clarification. It was coined by Gibson (1979) to describe an animal's perception of the environment: "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*". More precisely, Gibson's description involved the *interaction* of the animal with the environment. This is the sense in which it has been used in education,

Figure 1. Revision of Bloom's Taxonomy of learning objectives (Krathwohl, 2002).

		Knowledge dimension			
		A. Facts	B. Concepts	C. Procedures	D. Metacognitions
Cognitive Process Dimension	1. Remember				
	2. Understand				
	3. Apply				
	4. Analyse				
	5. Evaluate				
	6. Create				

emphasising active engagement by the learner with the educational environment—*affordances of educational technologies offer learning activities (including mental activities), to be enacted by the learner to achieve learning goals* (this author's definition). This definition is examined in the next section to derive a categorisation of distinct affordances of educational media and technologies.

2. Learning affordances of educational media and technologies

2.1. Various contexts for the term "affordances" in the educational literature

The term "affordances" appears in slightly different contexts in the education literature (Bower, 2008; Collins, Neville, & Bielaczye, 2000; Koumi, 1994 Laurillard, Stratford, Luckin, Plowman, & Taylor, 2000), as follows.

- render unto each medium what it does best (Collins et al., 2000)
- (identify) the affordance requirements of a learning task and how they can be satisfied by the inherent affordances of e-learning technologies (Bower, 2008)
- given a learning task, assign it to the medium that is best suited for it (Koumi, 1994)
- Laurillard et al. (2000) looked at only one medium, a non-linear narrative medium, and characterised as affordances: a collection of design features that would assist students to maintain a narrative structure, e.g. "a suggested answer - as feedback on their conceptions". The authors emphasise narrative coherence:

> Narrative ... aids recall through its causal links and signposting ... headings, textual signposts and paragraphing. It has both cognitive and affective impact, performing an essential organising function for the learner.

2.2. Fifteen learning affordances of educational media and technologies

Koumi (1994 and 2006 pp. 47, 65, 66) distinguished 15 attributes of educational media and technologies that can facilitate learning. These are the affordances listed in Figure 2.

Of the 15 affordances in Figure 2, ten overlap with affordances posited implicitly by other authors above. However, those authors do not directly address the following affordances.

- provision of realistic experiences
- motivational influences
- student reactivity
- variable size and duration of the learning package
- adaptivity

These five affordances are relevant to the arguments in this paper, as will be seen.

2.3. A preview of the 8 affordances to be discussed for video and print

In subsequent sections, the affordances that video and print are distinctively capable of yielding will be examined separately in order to surmise the learning outcomes that can be enabled by hybrid video–print packages. The main affordances that will be discussed for video are:

- optimal pedagogic design—for cognitive engagement and constructive reflection
- personalisation of the teacher
- motivational influences
- exceptional presentational attributes
- provision of realistic experiences

Figure 2. Fifteen affordances of educational media and technologies.

Presentational Attributes and Realism

1. **Symbol system** – the types of symbols the medium uses to communicate, e.g. text, graphics, moving images, chronological sequencing, sound.
2. **Motivational** Influences – engagement and motivation are crucial to learning.
3. **Personalisation** of the teacher, alleviating isolation – an advantage of video over print.
4. **Provision of realistic experiences**

Learner-Technology Interactions

5. **Networking** – enabling interaction between learners and teachers, online or face-to-face
6. **Adaptivity** – the medium is able to adapt its provision to suit an individual's needs (emulating the ability of an expert human teacher who addresses the needs of individual students)
7. **Interactivity** – an action by a student receives feedback from the medium, e.g. different levels of help are provided depending on students' inputs into a dialogue box
8. **Student Reactivity** – prompts for student activity, including mental activity (for which answers can be suggested, as in the self-assessed video-print combinations in this paper)

Ease of use

9. **Navigability** – ease with which users can move through the material to find particular items
10. **Surveyability/Browsing** – an advantage of static print over time-based audiovisual materials
11. **Legibility** – the amount of data that can be viewed comfortably (e.g. printed multi-page data)
12. **Controllability** – how much influence students can exert over how they use the medium

Choice of Time, Place and Duration

13. **Choice of When (and Where) to study** – afforded by self-paced study in contrast to a fixed course schedule (e.g. in face-to-face classes).
14. **Variable Size/Duration of the learning package** – afforded by segmented media materials compared to non-segmented.

Media-specific Pedagogic Designs

15. **Optimal pedagogic design for each technology/medium**
    Each educational technology/medium can be well or badly designed for cognitive engagement, constructive reflection, and hence learning.

    It is crucial that *optimal pedagogic design* is regarded as an affordance. If any technology or medium is designed badly, the potential of every other affordance is compromised.

The first three of these affordances will be discussed in terms of a substantial set of narrative design principles. The final two will be examined by considering pedagogic roles that video is outstandingly capable of yielding.

The affordances that will be discussed for print are:

- navigability
- surveyability/browsing
- legibility

2.4. A preview of the 7 affordances to be discussed for our three video–print combinations

The remaining seven of our fifteen affordances are relevant to video–print combinations.

Two of the seven, *controllability* and *choice of when/where to study*, are yielded by both video and print. These can enhance learning in general and apply to all three of the video–print combinations described in this paper.

Another two affordances, *variable size/duration* and *student reactivity*, are relevant to segmentation and self-assessment, respectively, as noted in Figure 2.

The final three affordances, *interactivity*, *adaptivity* and *networking*, are absent from the pure form of our three video–print learning packages—an absence that points to some learning limitations, to be discussed.

3. Two overriding learning affordances of video: optimal pedagogic design and presentational attributes

As noted in Figure 2, an indispensable affordance of any medium is its ability to secure learners' cognitive engagement and constructive reflection—its pedagogic design.

3.1. Optimal pedagogic design for video

In the case of video, the skills of authors to secure cognitive engagement and constructive reflection (hence learning) are vastly underestimated. Figure 3 offers a minimal framework of indispensable pedagogic design principles (précised from Koumi, 2006, Chapters 5–6).

Implementing the design principles in Figure 3 is not trivial. Each principle has several versions and needs interpretation as to *whether* and *how* it should be used to accommodate the target audience, the learning context and the learning objectives (Koumi, 2006, p.100).

Moreover there is often an interaction between principles. For example, principle 7d requires that images should reinforce the narrated words and vice versa. However, the need to restrain image-word density (6b) could require the image to be *irrelevant* rather than reinforcing the words. This might be the case when some narrated guidance is crucial (like signpost 2c, describing what to look out for); such a case would call for an *irrelevant* image, like a general backdrop, in order to avoid diluting the crucial guidance.

Another aspect of Figure 3 is that the principles embrace a narrative structure, delivering a *video story*. As noted earlier, narrative coherence was the main concern of the study by Laurillard et al. (2000). Indeed the cognitive efficacy of narrative structure has been proposed by many writers, such as Gudmundsdottir (1995), Gibson (1996) and Laurillard (1998).

Also, a well-sculpted story, being engaging, has *motivational* as well as cognitive effects—hence potentiating video's *motivational* affordance: crucial for learning[2]. This affordance is also addressed specifically by design principles 1a (e.g. *delighting*) and 1b (e.g. *creating suspense*). In addition, principle 3c, *establishing relevance for the learner*, is a motivational incentive for cognitive engagement.

Another affordance, *personalisation of the teacher*, is addressed by principle 5b (requiring the teacher to look/sound relaxed and confident, and to speak conversationally).

Figure 3. A framework of pedagogic design principles for each chapter of the video story.

*Categories 3 *(Facilitate Cognitive engagement)* and 4 *(Enable Construction of knowledge)* enable active construction of knowledge rather than passive reception, hence affording *student reactivity* (Number 8 in Figure 2).

1. Hook (a. capture attention, b. sustain interest)
- a Shock, surprise, appetise, delight
- b Create suspense, entertain, fascinate/captivate

2. Signpost
- a Distant Signpost: what's coming later
- b Chapter Heading: what's next?
- c Focus: what to look out for next
- d Educational Rationale: why are we doing it?

3. Facilitate Cognitive engagement*
- a Pose questions
- b Encourage prediction
- c Establish relevance to personal life

4. Enable Construction of knowledge*
- a Words *not duplicating* images
- b Pause commentary for contemplation
- c Invent visual metaphors

5. Sensitise
- a Consistent style
- b Personalise the teacher

6. Elucidate
- a Vary tempo to indicate syntax
- b Restrain image-word density
- c. Alleviate Cognitive Complexity
- d. Enhance Legibility / Audibility

7. Reinforce
- a Repetition (with a different angle)
- b Re-exemplify
- c Compare / Contrast
- d Synergy between words and images

8. Conclude / CONSOLIDATE
- a Chapter Ending
- b Summarise key features
- c Integrate complementary materials

3.2. Exploiting video's presentational attributes—potent pedagogic roles for video

Pedagogic design, *motivational influence* and *teacher personalisation*, just discussed, are three of the five affordances of video that were posited as facilitating learning. The other two, *presentational attributes* and *provision of realistic experiences*, will be addressed by discussing pedagogic roles that video is outstandingly capable of yielding.

Figure 4 lists 34 pedagogic roles that exploit video's presentational attributes to powerfully facilitate learning.

Most entries in the list have several versions and applications. This is explicitly noted for many entries, since they include subdivisions. For example in Domain 4 (demonstrating skills), each of the six entries lists three or more different skills. There are also several entries for which the subdivisions are not listed explicitly. For example, the following variety of video clips all involve a *composite image* (entry 1.1)

- *fleshing out* skeletons in biology or archaeology with slowly superimposed graphics
- *graphically superimposing* geological strata lines on a freeze of a cliff face—the lines would be absent to start with, then superimposed on then off, then again on and off
- *split-screen*—e.g. a loaded beam on the left with a shot of the strain gauge on the right
- *highlighting* parts of a picture while dimming other parts—to help discrimination
- *chroma-key*—a presenter beside a screen onto which another video clip is keyed

Figure 4. Potent pedagogic roles for video: techniques and teaching functions enabling learning.

1. Facilitating COGNITION
1 **composite images,** e.g. split screen, superimposition
2 **animated diagrams** exploring processes
3 **visual metaphor/analogy/representation**
4 **illustrating** concepts with real examples
5 **modelling** a process by judicious simplification
6 **juxtaposition** of contrasting situations
7 **simulating** variable features
8 **condensing time** by editing real life
9 **narrative power** through synchronous narration and pedagogic design

2. Providing realistic/amplified EXPERIENCES by showing otherwise inaccessible:-
1 **movement** with synchronous location sound
2 **viewpoints** e.g. aerial, undersea, microscopic, extreme close-up
3 **places** e.g. dangerous/overseas locations
4 **3D**, by good lighting & moving object or camera
5 **slow/fast** motion
6 **people/animals** interacting, real or drama
7 **chronological** sequence and pacing
8 **resource material** for viewers to analyse
9 **one-off or rare events,** including archive film
10 **staged events** e.g. dramatisation, experiments

	3. Nurturing AFFECTIVE characteristics
activation resolve motivation	1 **galvanize / spur into action**, provoke viewers to get up and do things
	2 **motivate a strategy** by showing its success
	3 **stimulate** appetite to learn, e.g. enthuse by revealing the fascination of the subject
attitudes emotions feelings	4 **change attitudes/appreciations**, e.g. engender empathy
	5 **alleviate isolation of the distant learner** by showing/hearing the teacher or peers
	6 **reassure, encourage self-efficacy**
	7 **authenticate academic abstractions** by showing them solving real-life problems
	8 **create sense of importance,** e.g. by using famous presenters

4. Demonstrating SKILLS
1 **manual/craft**: making learning aids, cookery, painting, designing
2 **body movement**: dance, fitness routines, athletics
3 **reasoning**: problem solving, planning, brainstorming
4 **interpersonal**: counselling, interviewing, teamwork, classroom teaching
5 **verbal**: language proficiency, singing, recitation, authoring
6 **studying**: researching information, exam strategy, collaborative learning
7 **technical**: laboratory, mechanics, nursing

3.2.1. The pedigree of the 34 pedagogic roles for video

The claim that the 34 pedagogic roles for video are potent (add distinctive value to learning) derives largely from expert teachers' opinions rather than from empirical research. Their provenance is as follows.

About half of the 34 roles correspond to the "video-distinctive added-value list" drawn up in the 1980's by the UK Open University's *Broadcast Allocations Committee*, with the purpose of ensuring cost-effective use of video. This list comprised pedagogic roles that video could deliver outstandingly well compared to other available media. OU Course Teams had to make a compelling case that the learning outcomes they intended for video really did need the pedagogic roles that video was distinctively capable of yielding. And they had to supply convincing arguments that other cheaper media would be less effective. Through the years, this procedure led to the compilation of 18 roles that were adjudged by consensus and research to exploit the distinctive strengths of video (Bates, 1984—Appendix A).

These 18 have been expanded into the 34 categories in Figure 4 mostly due to further deliberation during 10 three-month courses on Educational TV for Development, run at the BBC between 1982 and 1994 (Koumi, 2006, p. 3, 99). Since then, workshops by this author have led to further refinements and to the categorisation into the four domains of Figure 4.[3]

3.2.2. Learning is facilitated by video's presentational attributes

The basis of the learning-facilitation claim for the pedagogic roles in Figure 4 is the rich *symbol system* of video—its presentational attributes. These include:

- moving images with synchronous narration and location sound
- real-time or slow motion
- real-life or diagrammatic
- real or dramatised behaviour (can include comparing styles of personal interaction)
- extreme close-ups
- chronological sequencing and pacing of sound and images (e.g. enabling the display of body language and the phrasing of speech)
- visual metaphor
- specially constructed physical models to represent objects or concepts
- camera moves, zooms and framing
- customised lighting to "sculpture" objects (hence bring out their three-dimensionality)
- shot transitions (including editing to condense time)
- composite images, e.g. split-screen, superimposition (including key-word screen-text)
- varying format (e.g. a segment in studio, then on location, interspersed with animation)

3.2.3. The nature of the four domains of pedagogic roles

The above presentational attributes of video are the techniques that are shown distributed between the cognitive and experiential domains of Figure 4 (Domains 1 and 2). The techniques in Domain 1 facilitate learning and those in Domain 2 engender realism.

Domains 3 and 4 both comprise teaching functions rather than techniques—affective functions in Domain 3 and skills functions in Domain 4.

These points are elaborated in subsequent sections, as are the relationships between domains.

3.2.4. Video's presentational attributes are potentiated by optimal pedagogic design

It has been claimed above that video can achieve the 34 pedagogic roles in Figure 4 distinctively well due to its rich presentational attributes and that these can result in learning facilitation. But as noted

in Figure 2, this potential will be compromised if the design of the video is inferior. It has to be designed so that it actively facilitates learning, with a substantial set of pedagogic design principles such as those in Koumi (2006), summarised in Figure 3.

4. Learning through the four domains of video's pedagogic roles

A considerable number of studies have investigated the claim that video can facilitate learning through the pedagogic roles of Figure 4.

4.1. Learning through the video techniques of the cognition domain

4.1.1 Learning ANTICIPATED through the techniques of the cognition domain

Provided a video has been well-designed pedagogically, the learning outcomes of the techniques and teaching functions in the cognition domain are posited in Figure 5.

4.1.2 Evidence of learning through the techniques of the cognition domain

Figure 5 (anticipated learning), as well as Figure 4 (pedagogic roles for video), derives from experts' opinions rather than empirical research. As for evidence, many studies have shown that video helps learning, summarised in Paulsen and Bransfield (2010), Saltrick, Honey, and Pasnik (2004) and Wisher and Curnow (2003). This is despite the fact that the videos investigated were produced without the benefit of comprehensive design principles such as those summarised in Figure 3.

4.2. Learning through Domain 2—provision of realistic/amplified experiences

The experiences listed in Domain 2 are of two types: those that are true to life and those that amplify life-experiences.

4.2.1. Facilitation of learning through depiction of real-life experiences

Apart from some abstract subjects like logic and pure mathematics, learning in the cognitive domain is largely concerned with knowledge about the real world, therefore when learners experience the real world (vicariously but realistically) their study is grounded in context. Jonassen (1991) argues that context provides "episodic memory cues that make the acquired knowledge more memorable" (p. 37). McLellan (1994) pointed out that context for learning can be provided by an anchoring context such as a video or multimedia programme.

Figure 5. Learning anticipated through the techniques in Domain 1 of Figure 4 (Cognition).

1.1	**composite-image techniques** can aid synthetic, analytic and discrimination skills; for substantiation see section 3.2 for the variety of video clips illustrating these techniques
1.2	**animated diagrams** – for explaining dynamic processes: they help students to share the teacher's imagery; particularly powerful is interspersing real life with animation of obscured motion, e.g. the motion of the diaphragm of a person with breathing difficulties
1.3	**visual metaphor/analogy/representation** – to concretise abstract processes
1.4	**illustrating** abstract concepts with evocative real-world examples, hence making the concepts more tangible. (Note the overlap with domain 2 - the presentation of real-world examples would entail experiential techniques, such as *staging events* or *visits to dangerous locations*. However, domain 2 is **what** we show, whereas 1.4 is a **why** we show it (a **teaching function**)
1.5	**modelling** a process with a tailored, simplified version – which scaffolds learning by showing only the pertinent features. (Like 1.4, this is another teaching function.)
1.6	**juxtaposition** in quick succession, of contrasting situations/processes – to aid discrimination
1.7	**simulating variable features** – thereby students can be given control of the parameters and chose which features to view, and in which order
1.8	**condensing time** by pruning real-world processes (e.g. editing out non-salient events) thus bringing the duration within the viewer's concentration span
1.9	**narrative power** – narrative creates coherence and aids recall through its network of causal links and signposting (Laurillard et al, 2000). Additional respects in which narrative facilitates learning are discussed in Koumi (2006, Chapters 5 and 6).

Consequently, instructional video is often used to transport learners into the real world.[4] A particular example is learning how lab techniques are scaled up in industry (Koumi, 2006, pp. 90–91). Indeed, apart from *animation* and *visual metaphors,* all the roles in the cognition domain, involve real-life experiences.

The above arguments, which were focussed on cognitive learning, apply even more so to skills learning. Admittedly, many vicarious video experiences of skills need to be followed up by real-life practice, but the video depiction provides valuable grounding.

The same is true for all the affective roles—they all involve showing real-life experiences and behaviour. For example, changing attitudes towards people might involve seeing various contrasts *in situ*, like peoples' socialising behaviour (Bates, 1984, p. 246).

The strength of these influences is mediated by the realism of the vicarious experiences.[5]

4.2.2. An added bonus of the experiential domain—Amplified Realism
Beyond mere realism, items 2, 5 and 9 of the experiential domain of Figure 1, *extreme close-ups*, *slow/fast motion* and *staged events*, supply *amplified realism* that cannot be experienced in real life.

For example, an *extreme close-up* of a carpenter's chisel preparing a depression for a mortice lock; this shot can be so tight that trainee carpenters could not experience the view in real life because they would need to stand too close for their eyes to focus.

Regarding *slow/fast motion* (item 5 of the experiential domain), this could display

slow motion of

- a bird in flight; or predators hunting
- air-bags expanding in a car crash
- a vibrating string, showing a clear image of the shape of the string

fast motion of

- cloud movement; flowers growing; bacteria dividing
- a bird, nest-building; a spider, weaving its web
- the 12 h tidal cycle speeded up 1,500 times

Under item 9, *staged events*,

- a carefully controlled spray of water under special lighting conditions to demonstrate a rainbow that is in the form of a complete circle
- in a safety training video, staged accidents, made to look real by contrived editing

4.3. The extent to which video engenders affective changes
To what extent can video influence motivations and emotions, and over what time frame?

Social learning theorists suggest that observing a model via video is a viable method of learning a new attitude (Miller, 2005). In contrast, affective-cognitive consistency theorists suggest that the affective component of the attitude system may be changed by first changing the cognitive component through providing new information, e.g. as in anti-smoking or literacy campaigns on TV.

Altinay, Brown, and Piccoli (2012) report a more nuanced result in which the cognitive component did not correlate with attitude change. They found a significant change in attitude and intentions to

act following the viewing of a video on climate change which was *personally framed* (framed in terms of the effect on the individual). A video *framed globally* and one *depicting facts only* did not reach significance on attitude change.

Zimbardo & Leippe (1991, p.154–58) report the following research findings on attitude change. A complex message was found to be more persuasive when presented in writing "presumably because, it could be better comprehended if it was read", while an easy-to-understand message was most persuasive when presented on video. Other findings were that experts and likeable presenters on video were much more persuasive than unlikeable non-experts and the effect was stronger for video than for print.

Other scholars (Ann Renninger, Bachrach, & Posey, 2008; Azevedo, 2006) note that sustained changes in students' interest need multiple triggers rather than through video alone. This perception is reflected in the use of the term *nurturing*, rather than *changing*, in the affective domain of Figure 4.

4.4. Evidence of learning skills through video demonstration

Typing *video demonstration of skills* into Google results in a billion entries, including many videos demonstrating skills, in every category of the skills domain. But how effective are such videos?

There is a large body of research regarding the efficacy of cognitive apprenticeship (Cash, Behrmann, Stadt, & Daniels, 1997; Collins, Brown, & Holum, 1991).

Collins et al. (1991) characterise cognitive apprenticeship in terms of four main phases: modelling, coaching, scaffolding and fading. In modelling, the *Master* demonstrates the target task and exposes the thinking behind it. The master then coaches the apprentice who undertakes activities towards becoming an expert. These activities are designed to support or *scaffold* the learning. For example, the activities could be subtasks or simplified versions of the task. *Fading* refers to progressive withdrawal of the scaffolding as the learner becomes more proficient.

Video demonstration of skills covers the first phase, modelling. The other three phases are invariably necessary to become an expert; however, the efficacy of modelling alone, using video, has been exemplified in several studies, while being challenged in others.

Nova Scotia Online Learning (2005–2011) have produced creditable videos in their virtual campus apprenticeship programme, which has produced an average of 800 graduates per year between 2005 and 2011. Some of the videos, for coaches, encompass both manual skills and teaching skills.

Kemper, Foy, Wissow, and Shore (2008) found that 59 of the 61 clinicians who viewed demonstration videos on communication skills judged that their skills had much improved.

Donkor (2010) showed that video was superior to print materials in practical skills and craftsmanship of block-laying and concreting.

In contrast, a study carried out on 40 students of nursing and obstetrics by Mouneghi, Derakhshan, Valai, and Mortazavi (2003), showed that live demonstration was superior to a video demonstration for the skills of *changing a wound dressing and washing the hands*. However, students' grades were still high after video demonstration, so the authors concluded that video can be a suitable substitute whenever live demonstration was difficult to manage.

All four studies above show that video can be effective in the learning of skills, although the fourth showed that live demonstration was superior to video.

4.5. Caveat: a fundamental problem with media comparison studies

Care should be exercised in interpreting the third and fourth studies above. There are many such media comparison studies that suffer from a fundamental problem: how well were the media designed? Neither of the above studies gave a description of the video design.

Donkor's video was based on existing print materials, but Donkor would have attempted to design as good a video as possible, so possibly some pedagogical enhancements were incorporated, making the video pedagogically superior to that of the print materials.

Conversely, the pedagogic potential of video may have been under-achieved (which would strengthen Donkor's conclusion). For example, if the video treatment was based strictly on the print treatment (in the attempt to compare like with like), the full potential of video would be under-achieved. This is because each medium has distinctive presentational attributes that need to be fully exploited by choosing distinctive treatments of the topic. For example, in the topic of mixing cement, the print material would probably start with the beginning of the procedure, whereas the video had better start at the end, showing the desired consistency of the final mix before jumping back to the start of the mixing. The video had also better focus on the movements of the operator. So rather than comparing like with like, Donkor's study may have been comparing (bad) apples with oranges.

Similar issues concern the study by Mouneghi et al. (2003). In a video recording of a manual skill, special lighting is needed to bring out the three-dimensionality. The demonstrator's movements also need care so as not to obscure the camera's view. Other techniques, like cutting to an extreme close-up at critical points, could serve to make the video experience *more* informative than the live demonstration. Also more informative would be to position the camera so that viewers get a virtual experience of personally performing the skill—i.e. place the camera close to the eye-line of the demonstrator. In a live demonstration, this viewpoint would need all trainees to stand just behind the demonstrator's ear—not possible. Moreover, to achieve optimum video treatment, the demonstrator's narration needs to accommodate the special shooting techniques, using design principles such as those in Figure 3. It is unlikely that such skills were used by the researchers, since they made no mention of video design issues.

Such considerations point to critical flaws in media comparison studies. In order to be fair to each medium, we would need to employ creative practitioners and allow them adequate resources and thinking-time to exploit the full potential of each medium's presentational capabilities.[6] This means not only good design but the concept of *comparing like with like* has to be abandoned in favour of judging which *different treatments* of the topic best exploit the affordances of the different media.

5. Taxonomy of learning outcomes afforded by video

The array of pedagogic roles in the cognitive domain of Figure 4 suggests a wide range of learning outcomes that can be afforded by video, as expounded in Figure 5, and supported in general terms by the research literature. It has been argued that such learning outcomes are helped by the realism enabled by the experiential domain of Figure 4. More crucially, all the presentational attributes need to be potentiated by effective pedagogic design, as in Figure 3.

These outcomes will now be discussed in more specific terms through the two-dimensional matrix of cognitive learning goals introduced in Figure 1. This is reproduced in Figure 6 with a shaded cell as an example of how to interpret the matrix. This cell indicates a learning outcome of type 4/C, *Analyse* some *Procedural knowledge*. A specific example of this, in the topic of metalwork, could be, *differentiate between welding and soldering*.

The Revised Taxonomy deals largely with the cognitive domain. However, this focus is not entirely exclusive. Firstly, the cell create/procedures in Figure 6 does include *production of skills* in the expanded version of the taxonomy, shown in Appendix A (Figure 21). Secondly, the expanded

Figure 6. A typical cell, 4/C, in the Revision of Bloom's Taxonomy (Krathwohl, 2002).

		Knowledge dimension			
		A. Facts	B. Concepts	C. Procedures	D. Metacognitions
Cognitive Processes	1. Remember				
	2. Understand				
	3. Apply				
	4. Analyse				
	5. Evaluate				
	6. Create				

Figure 7. Learning outcomes that can be achieved with non-segmented video viewing.

		Knowledge dimension (**overviews** rather than fine detail)			
		A. **Facts**	B. **Concepts**	C. **Procedures**	D. **Metacognitions**
Cognitive processes	**1. Remember**				
	2. **Understand**				
	3. Apply				
	4. Analyze				
	5. Evaluate				
	6. Create				

version of "Metacognitions" includes "self-knowledge" and this encompasses most of the affective teaching functions in Figure 4.

In Figure 7, a **bold** font has been used for those learning outcomes that can be achieved with non-stop viewing of self-standing video (no complementary print), it being understood that the video has been diligently designed for effective learning (Figure 3) and that optimum use has been made of video's many potent pedagogic roles (Figure 4). In which case, viewers can be enabled to *remember* and *understand* all four knowledge categories: *facts, concepts, procedures* and *metacognitions,* for the following reasons.

The types of learning in Figure 5 clearly cover *1 Remember* and *2 Understand* for knowledge categories *A Facts, B Concepts, C procedures*. Sections 4.2 and 4.4 regarding skills also indicate that *3 Apply* can be achieved (to an extent, hence only pale shading).

As for *D Metacognitions*, in the expanded taxonomy (Figure 21), this has subcategories, *learning strategies* and *self-knowledge*. The first subcategory, *learning strategies*, can be targeted by *modelling a (learning strategy) process* (*1.5* in Figure 4). The second, *self-knowledge*, can be touched on by *1.3 metaphor* in Figure 4 (e.g. metaphor for fear of change). Also note that most of the affective teaching functions in Figure 4 directly facilitate self-knowledge.

The cells in Figure 7 that are not highlighted indicate the kind of learning that cannot easily be achieved through non-stop viewing of video. That is, non-stop video is not an appropriate means of achieving the three highest level cognitive processes, *analyse, evaluate, create*. Moreover, even for the learning outcomes that are more easily achieved, non-stop video is more suitable for providing *overviews* of the four knowledge categories rather than fine detail (hence the bracket added to the top line of Figure 7).

Nevertheless, note that *remembering* and *understanding* an *overview* of a knowledge topic is a useful (often an essential) *precursor* of higher level processing of details. The reverse can also be true—an overview can provide a useful *consolidation* after a learner has undertaken concentrated study of details, but has been left with a fragile grasp of the big picture.

6. Print excels over video for many cognitive learning tasks

Assuming that we do have the resources to get the best out of each medium, there are many circumstances and learning tasks in which well-designed print excels over video.

Despite the wide variety of teaching functions for which video was used (above), the UK OU believed that print was adequate for most OU study. Learning tasks for which print is more suitable than other media are noted below, with the pertinent affordance appended.

- self-paced concentrated study of fine detail (Bates and Poole, 2003, p. 175), e.g. equations, diagrams, closely reasoned argument (the ***surveyability*** affordance)

In contrast, as noted earlier (Figure 7), non-stop video is more suitable for providing overviews rather than fine detail and for enabling lower level cognitive processes such as *remembering*, *understanding* (and, to some extent, *applying*).

- where the student benefits from browsing and selecting, which is easier with print due to tables of contents, headings and indexes, and due to random access (rather than the serial access of visual search on video). For example, when students revise for an exam they sometimes need to search their printed booklets for scattered information on a particular point (the ***navigability*** affordance)
- when students need self-paced study of information in quantity, e.g. glossary, multi-page charts, DNA sequence of a gene, complex study guide (the ***legibility*** affordance)

6.1. Pedagogic design of stand-alone print materials

From the start in 1970, the UK OU printed units followed a tutorial-in-print format in which learners are asked questions after short, manageable chunks of learning, in order to *check that they have understood the ideas being discussed and can comment on them or apply them* (Rowntree, 1994). These exercises were followed immediately by feedback in the form of printed model answers or suggestions. Hence, the printed units followed the *self-assessed, segmented* format, which will be discussed below for video–print combinations.

The printed units involved many more design principles, such as conversational style of writing, use of illustrations, wide margins for students to make notes.

6.2. Learning outcomes afforded by the print medium, compared with video

What learning tasks can the print medium enable students to achieve, compared to video? Firstly, the four knowledge categories, A, B, C, D—can all four be achieved?

Figure 8 excludes the final three cognitive processes, for the same reasons as those given for video in the discussion of Figure 7.

Comparing video and print, it is suggested in Figure 8 that print may not be as good as video for dimension B, *abstract concepts* (since video can illustrate these with real examples) and dimension C, *procedures (skills),* since video can demonstrate skills, as noted in Sections 3.2 and 4.4.

Now for cognitive processes: comparing print with video. *Applying* knowledge is better achieved through print for facts and metacognitions, due to reflection-time, as indicated in Figure 9. Ditto for

Figure 8. Learning outcomes probably better achievable through video than through print.

		Knowledge dimension			
		A. Facts	B. **Concepts**	C. **Procedures**	D. Metacognitions
Cognitive processes	1. **Remember**				
	2. **Understand**				
	3. Apply				
	4. Analyze				
	5. Evaluate				
	6. Create				

Figure 9. Learning outcomes better achievable through print than through video.

		Knowledge dimension			
		A. **Facts**	B. Concepts	C. Procedures	D. **Metacognitions**
Cognitive processes	1. Remember				
	2. Understand				
	3. **Apply**				
	4. **Analyze**				
	5. **Evaluate**				
	6. Create				

Analyse and *Evaluate*. In fact reflection-time is also likely to enable better achievement of *Remember* and *Understand*—again for facts and metacognitions.

Notice that Figure 9 qualifies the assertions in Figure 7. That is, although video affords learning outcomes for the knowledge dimensions of *facts* and *metacognitions*, print excels over video in these dimensions and in the extent to which they are cognitively processed.

What about *create*? The ability to create is severely limited by print being a one-way medium (as is the video envisaged in this paper)—summarised in Figure 10. The potential to achieve creativity through interactive/adaptive, dialogic teaching/learning is examined later.

7. Video–print combinations

It was argued in Section 5 that, even without complementary print, well-designed video can fulfil many potent pedagogic roles (Figure 4), leading to several learning outcomes (Figure 7). However, the power of video can be enhanced considerably when it is complemented with print, in a "video-print hybrid".

Three versions of self-assessed video–print hybrids will be examined. One version involves non-segmented video, complemented with preparatory print material. In the other two versions, the videos are divided into short segments, one version having narration on the video, while the other has only printed commentary.

The three versions will be described in detail before characterising them in terms of the Revised Bloom's Taxonomy.

7.1. Self-assessed preparatory print material for non-segmented video

At the UK Open University, TV programmes were complemented with *broadcast notes*, distributed in advance, which prepared students for the TV by providing general learning goals, summarised the content and offered post-viewing self-assessment questions (normally with suggested answers). The rationale for self-assessment includes the following.

(1) consolidation of video learning, i.e. the questions stimulate retrieval of what's been learned (Shepherd & Godwin, 2004), and the suggested answers offer feedback

(2) pre-knowledge of post-viewing assessment encourages **watching** the video

Figure 10. Creative outcomes are difficult to achieve (↓) with any one-way medium.

		Knowledge dimension			
		A. Facts	B. Concepts	C. Procedures	D. Metacognitions
Cognitive processes	1. Remember				
	2. Understand				
	3. Apply				
	4. Analyze				
	5. Evaluate				
	6. **Create (↓)**				

(3) pre-knowledge of post-viewing assessment encourages **attentive** viewing
(4) sharpens producer's teaching intentions
(5) the answers can be collected in a survey as evidence for evaluating the video
(6) teaching that is not suitable for video can be relegated to the printed broadcast notes

All six points of rationale apply to the segmented video–print media described below, in which the complementary notes are inextricably integrated with the video.

7.2. Video designed to be viewed in short segments, self-assessed via complementary notes

The contrast was made above between the suitability of print for concentrated study and of video for providing image-based overviews and lower level knowledge processing. There are also learning tasks that are a hybrid of *concentrated study* and *image-based overview*, for example *tasks that need concentrated study but flexible access to dynamic visual material*.

During the 1980s, materials requiring such tasks were distributed extensively by the UK OU on video cassettes, with complementary notes and self-assessment questions on paper (Koumi, 2013b).

7.2.1. Learners invited, but not obliged, to self-assess

The videos in the UK OU hybrids were not intended to be viewed non-stop—they were designed to exploit the stop–start facility of the video player, inviting student activities during the stops (Crooks & Kirkwood, 1988). To this end, the videos included captions every few minutes that asked the viewer to stop the video and carry out a self-assessment activity (SAQ) described in the complementary notes. For example, the caption could read as in Figure 11.

The videos were indexed, for example with a time-code showing the video's duration. Alternatively, when less precision was acceptable, the index incremented every few seconds, as in Figure 11 (top right). This allowed the *video notes* to reference specific segments of the video. Hence, the video and print were inextricably integrated into a *composite* video–print hybrid.

Nowadays the print need not be in a separate paper booklet. Instead, within a VLE or e-Book, the print can be viewed as screen-text. Also, the video would not need a *stop-the-video* caption, since the video could stop automatically wherever the designer wanted to invite student activities. However, the affordance

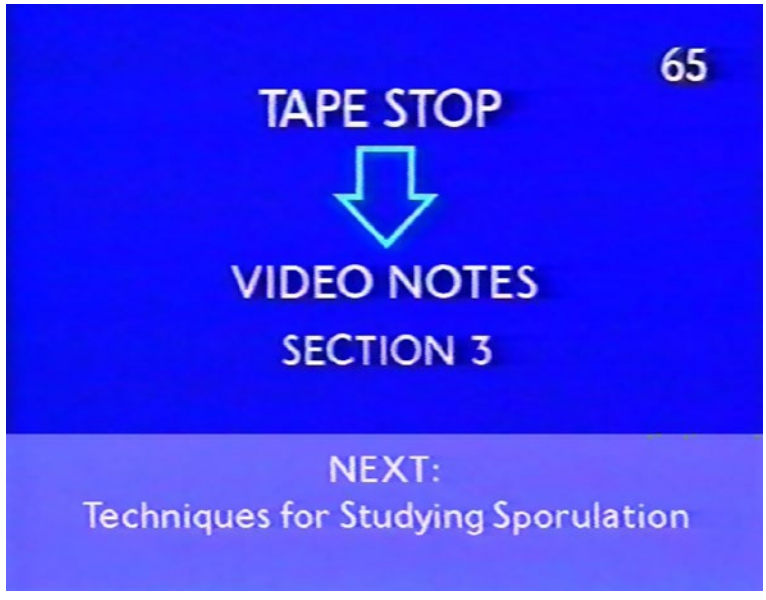

Figure 11. A caption in S325 Video 4, Sporulation, inviting students to stop and do activities in video notes Section 3 (although they could choose to continue with the NEXT segment).

of *student control* could still be encouraged: at each video stop, students could be told what comes next on video (as in Figure 11) so that they could choose whether or not to continue viewing before attempting the SAQs. Granting students the autonomy to defer self-assessment builds self-reliance, but could jeopardise proximate learning. Several studies, below, are relevant to this reservation.

7.2.2. Studies reporting learning facilitation through segmentation without SAQs
Decades after the use of segmented materials by the UK OU, the idea of segmentation has re-surfaced, but *without* the inclusion of SAQs (Hasler, Kersten, & Sweller, 2007; Ibrahim, 2012; Mayer, 2005, Chapter 11; Spanjers, van Gog, & van Merriënboer, 2010). These authors report positive results when animations and videos were segmented, enabling learners to stop and reflect between each segment. For example, in one version, a 140-s animation on lightning formation stopped after each of 16 segments until the learner clicked *continue*. In another version, an animation stopped until the learner clicked on a choice of topics in a list, and that topic would be addressed by the subsequent segment.

Hence segmentation has been shown to enhance learning, even without SAQs, showing the powerful effect of allowing students to reflect on the content of a short media segment.

7.2.3. Studies that added SAQs to previous non-SAQ treatments
A priori one would expect learning to be further enhanced when students' reflection is focussed, through SAQs, onto the specific elements that the teacher intended to be learned. This expectation has been borne out in two studies that modified some of the above non-SAQ treatments by adding SAQs, resulting in improved positive effect.

Evans and Gibbons (2007) modified Mayer's bicycle pump animation so as to include SAQs after each segment (plus a simulation) and found considerable learning improvement.

Cheon, Crooks, and Chung (2014) adapted Mayer's (2005) lightning-formation animation by providing a pause after every four of the 16 steps. Students who were given embedded cued-recall questions during the pauses performed better than those who merely had to reflect during the pauses, irrespective of whether the text was spoken or written.

7.3. Two distinct versions of segmented video–print learning packages
One version of a segmented video–print learning package is a *video-led* hybrid, in which the video is pedagogically scripted and does most of the teaching, but where the supplementary print prompts self-assessment. In the second version, the video observes unrehearsed behaviour and the pedagogic guidance is supplied in printed form.

7.3.1. One type of segmented video–print hybrid—video-led
This type will again be illustrated with Video 4 on Sporulation from the OU Course S325 Biochemistry and Cell Biology (1985) (Figures 12 – 14).

Figure 14 shows two of the SAQs in the notes for Video 4.

Following SAQs such as those in Figure 14, there would be *suggested answers*[7].

The proportion of UK OU video that was designed in this form increased steadily, reaching 30% by 1994, and still rising in 2000. (After about 2002, the Open University moved away from *long-form narrative video* to use short clips, termed *video assets*, inside digital multimedia packages).

The average duration of a UK OU video was 30 min but students had to spend about 2 h studying the video–print package. In the above Sporulation example, the required study time was several hours. The 52-min video had eight segments (so average segment length was 6½ minutes, although

Figure 12. S325 Video 4, Sporulation. Tube neck inserted into a flame.

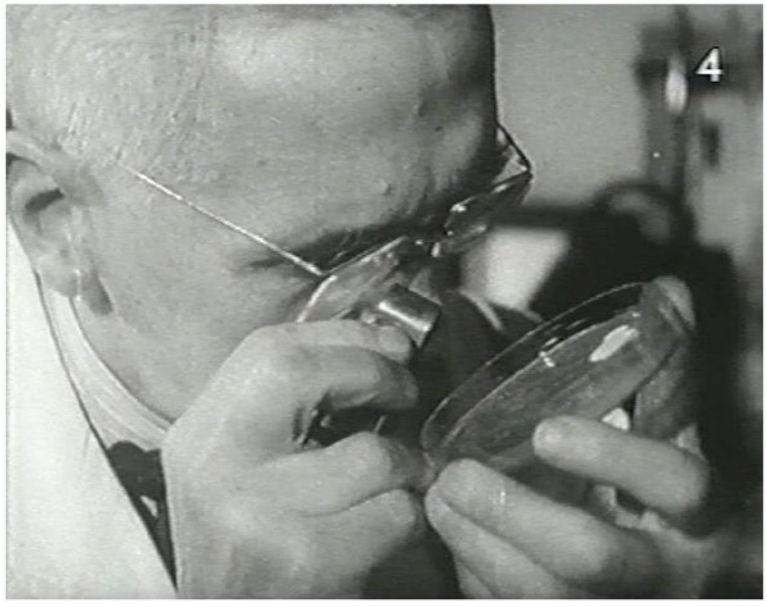

Figure 13. S325 Video 4, Sporulation. Fleming re-enacts his discovery of penicillin.

Section 2. Laboratory techniques in segment 2 of the video (video index 17 - 35)

Q 7 for Tape Stop 2. At the beginning of the video segment, Dr Dring inserted the necks of tubes into a flame before transferring material from one to the other. He said he wanted to prevent contamination. Can you think of TWO ways in which this procedure prevents contamination?

A relevant screenshot from the video is shown in FIGURE 12

Q 11 for Tape Stop 2. Penicillin is a fungal product that inhibits the growth of some bacteria. However, penicillin does not affect fully mature bacterial cells. Bearing this in mind, recall the film report of Fleming's discovery (video index 3-5) and critique what Fleming claimed he had observed.

A relevant screenshot from the video is shown in FIGURE 13

Figure 14. SAQs in the notes for video 4 of the Sporulation course.

two segments were 10 min long). The notes contained 55 self-assessment questions; these, together with the suggested answers, constituted comprehensive formative self-assessment.

7.3.2. A second type of segmented video–print hybrid

In the second version of a video–print package, all the study guidance is in print, relating to successive short segments of the video recording. For example, a teacher-training package might be in this style, with the video-clips being *fly-on-wall observational* recording of unrehearsed behaviour, such as video observation of classroom activity, without commentary on the sound-track. The printed material would contain pedagogic rationale for the classroom methodology and would suggest reflective activities (e.g. through peer discussion) related to the observational video. The examples in Figures 15–17 below are from video–print materials developed in Vietnam for Primary Teacher Education (Koumi, 2008).

The average length of segments in both examples was 3 min.

Figure 15. Work in pairs in a grade 5 Geography class.

Figure 16. Girl not concentrating on the handicraft work.

Figure 17. Self-assessment questions in the Vietnam Primary Teacher Education course.

1. Geography class for grade 5 *(the whole video was 14½ minutes, divided into 5 segments)*
Continue viewing the video from index 10:56 until 13:59. There is a caption at this point that tells you to stop and discuss the following question**:**

The teacher divided the mixed ability group of 4 pupils into two pairs of 2. If this is done randomly, one of the pairs might have both pupils of high ability, while the other has both of low ability. Is this appropriate for the assigned tasks, or should she ensure that each pair is mixed ability?

A relevant screenshot from the video is shown in FIGURE 15

2. Handicraft class for grade 1 *(the whole video was 17 ½ minutes, divided into 6 segments)*
Continue viewing the video from index 04:06 until 09:34

In the video clip, there were some negative behaviours. For example:
– playing in the lesson, at 07:34 to 07:42
– at 08:25 to 08:28 you can see a girl who does not concentrate on the work

Discuss what should be the teacher's reaction to these behaviours.

A relevant screenshot from the video is shown in FIGURE 16

During the teacher-education course, the self-assessment questions in Figure 17 could be carried out by individual in-service teachers. This is the "pure" form of video–print package, which lacks the ***interactivity*** affordance. However, the course recommended discussion in small groups, which was organised if scheduling permitted. The latter enhancement is a face-to-face version of the ***networking*** affordance discussed in Section 2. In a proposed online adaptation of the training course, this networking would be carried out online (Koumi, 2008).

7.3.3. Caveat: adding segmentation and self-assessment should not be an afterthought
Subdividing a long-form video story into chapters is a fundamental narrative technique. But chapters are not the same as segments that are to be self-assessed.

If self-assessment questions are to be answered by students, the teacher needs to judge learners' intellectual predicaments before segmenting. A segment needs to end when a coherent set of such intellectual predicaments needs to be addressed with self-assessment questions. This might not coincide with the "natural chaptering" of the narrative. On the one hand, coherent, non-trivial questions may need a segment to encompass *two* "narrative chapters". Conversely, a full narrative chapter might entail too many self-assessment question, so may need to be segmented into two subchapters.

8. Learning outcomes for the three types of video–print package

Having considered learning outcomes better achievable with the print medium than with video (Section 6) we would expect that the supplementary print has extended the potential learning outcomes of our three video packages. With this in mind, let's return to the learning outcomes that can be achieved with the three types. First, a summary of the three types.

(1) *NON-SEGMENTED VIDEO* (designed for non-stop viewing): A video that does all the teaching by itself (a type sometimes referred to as *long-form narrative*), without the support of printed material. However, if desired, some *video notes* could prepare students for the video and summarise it. Additionally, the notes could suggest post-viewing self-test questions.

(2) *VIDEO-LED* video–print package: Consisting of a *scripted* video plus printed video notes. All the teaching is done through the video narration (with a few points elaborated in the notes)

The video is in sections, designed to exploit the stop–start facility of the video player. Between sections, viewers stop the video and answer the questions in the video notes. The notes supply answers, which may sometimes elaborate, giving extra information that is not contained in the video.

(3) *PRINT-GUIDED* video–print package: Again, the video is in sections with interspersed questions. However, instead of scripted scenes, the video contains *fly-on-wall observation (*observation of

unrehearsed behaviour), such as the interactions between a teacher and students. There is no narration on the video. All discussion of the contents of the video is carried out in the printed study guide, through interpretation of the classroom events and through question and answer.

From now on, the judgement of learning outcomes in the knowledge dimension concern the *depth* of knowledge (or the *fine detail* in the knowledge). So strictly speaking the Revision of Bloom's Taxonomy would need a third dimension, *Depth*, to properly characterise the learning outcomes.

Bower, Hedberg, and Kuswara (2010) also take issue with the absence of *level of thinking* in the cognitive dimension, stating, "the extent to which the (cognitive processes) engage the level of thinking … depend upon the task itself and the students' level of cognitive engagement with it" (p. 182)

The Depth dimension is not presented explicitly below, but is implicit in the top line of the remaining Figures 18–20, which considers the degree of fine detail.

8.1. Learning outcomes for non-segmented video with supplementary notes

For non-segmented video (viewed non-stop), the supplementary notes could include post-viewing self-test questions, as described earlier. These notes could augment the range of teaching functions to include the third and fourth cognitive processing levels, *Apply* and *Analyse*, as depicted in Figure 18.

		Knowledge dimension (**still overview rather than fine detail**)			
		A. **Facts**	B. **Concepts**	C. **Procedures**	D. **Metacognitions**
Cognitive processes	1. **Remember**				
	2. **Understand**				
	+ 3. **Apply**				
	+ 4. **Analyze**				
	5. Evaluate				
	6. Create				

Figure 18. For non-segmented video, extra learning outcomes (3 and 4) are afforded by post-viewing exercises in broadcast notes (in addition to cognitive outcomes 1 and 2 through the video alone, posited in Figure 7).

		Knowledge dimension (**in finer detail**)			
		A. **Facts**	B. **Concepts**	C. **Procedures**	D. **Metacognitions**
Cognitive processes	1. **Remember**				
	2. **Understand**				
	3. **Apply**				
	4. **Analyze**				
	+ 5. **Evaluate**				
	6. Create				

Figure 19. Deeper learning outcomes afforded by short (video-led) segments supplemented by the questions and answers in the video notes (in contrast to the "overview" outcomes through non-segmented video plus supplementary notes—Figure 18).

		Knowledge dimension (**not as fine detail as Video-led**)			
		A. **Facts**	B. **Concepts**	C. **Procedures**	D. **Metacognitions**
Cognitive processes	1. **Remember**				
	2. **Understand**				
	3. **Apply**				
	4. **Analyze**				
	5. **Evaluate**				
	+ 6. **Create (skills)?**				

Figure 20. For print-guided video–print packages, perhaps an extra *creative* outcome is afforded by observing unrehearsed behaviour, with printed guidance.

However, as for video without notes (Figure 7), the *knowledge* would still involve little fine detail. This is because the notes can't easily add detail since they refer to a large, non-segmented amount of video content, e.g. 25 min.

8.2. Learning outcomes for the video-led, segmented video–print package

In the second type of video–print package (video-led), due to the fact that only **short** video segments are viewed, the **depth** of knowledge can be somewhat greater—finer detail and conceptually more dense. That's **without** the supplementary print. Now take that print into account—the questions and answers in the print can likely extend the learning outcomes to the fifth cognitive process—*Evaluate*—as summarised in Figure 19).

8.3. Learning outcomes for the print-guided, segmented video–print package

For the third type of segmented video–print package (print-guided), the video is observational, without commentary. So the teaching functions are a combination of the Print learning outcomes in Figure 9 and the video's **experiential** depictions in Domain 2 of Figure 4. Also included are some **skills** functions of Domain 4, in the above example of Vietnamese trainee teachers observing a master teacher's skills.

The conceptual density may not be as great as type 2 (video-led), because of the absence of simultaneous commentary to analyse what the video is showing. On the other hand, learners concentrate on observing **behaviour,** so they may achieve the basics of the final cognitive process, create (creating a classroom skill in the teacher-education example)—summarised in Figure 20.

8.4. Caveat. Limitations of one-way media

Don't be too ambitious. Cognitive processes 4, 5, 6 (analyse, evaluate, create) are very difficult to achieve with a one-way (transmissive) medium. For example, videos demonstrating classroom teaching methodology, even when supplemented with **printed study guidance** and **discussion** (as in the print-guided video example described above) also need supplementing with **teaching practice** and **formative evaluation**, through dialogue with a teacher-trainer and with the trainee-teacher's peers who can ***interact*** with and ***adapt*** to the individual learner.

This caveat accords with the contention in Bower et al. (2010), that transmissive technologies can serve lower order thinking processes, whereas later stages of the learning cycle require constructive, dialogic and co-constructive activities. Regarding constructive activities, it was noted for well-designed video, that categories 3 and 4 of Figure 3 (the pedagogic design framework) can provide constructivist encouragement and opportunities. Nevertheless, the involvement of peers, and especially the dialogic presence of the teacher-educator, are essential for the affordances of ***interactivity*** and ***adaptivity***—and hence of higher order learning.

9. Discussion

Bearing in mind the above caveat, teachers can view Figures 18–20 as a basis for judging which of the three video–print hybrids could achieve specific outcomes.

In addition, Figure 7 posits a substantial set of learning outcomes that are afforded by the presentational attributes of a well-designed video on its own (without complementary print).

More specific implications are discussed in the next two subsections.

9.1. Implications for teachers using video

There are several ways in which this paper can help teachers make effective use of video, whether in class or for learners' home consumption online.

The first requirement is that any video needs to be pedagogically designed, as discussed in Section 3.1, with design principles summarised in Figure 3. Secondly, the set of 34 potent pedagogic roles for video discussed in Section 3.2 (itemised in Figure 4) should be scrutinised to ensure that video's

presentational attributes are appropriately exploited to realise the teacher's intended learning outcomes. These provisos can vastly improve the effectiveness of video, affording the learning outcomes described in Section 5, depicted in Figure 7 in terms of the Revised Bloom's Taxonomy.

Thereby, Figure 7 would enable teachers to judge whether their intended learning outcomes can be achieved using video alone, without complementary notes. For example, a short video podcast (e.g. 3–6 min) could function as a robust introduction of a topic.

Section 6, regarding learning outcomes afforded by print, was largely directed towards subsequent sections that investigated *combinations* of print with video. However, many learning tasks were identified for which print is effective on its own (and superior to video in some cases, especially those that benefit from self-paced reflection time). Hence, these comparisons could help teachers' choose between video and print.

However, *combinations* of video and print can achieve wider and deeper learning outcomes than either print or video separately. Three types were illustrated in Section 7, all with self-assessment questions and suggested answers. In one type, the video is not segmented (intended to be viewed non-stop), compared with two styles of segmented video–print packages, one video-led, the other print-guided.

The extended learning outcomes afforded by these hybrids were discussed in Section 8, characterised in Figures 18–20, respectively. These Figures should enable teachers to judge which of the three hybrids could achieve the teachers' intended outcomes. This is particularly relevant for teachers who *flip their classroom*, whereby students watch a video of the learning content at home and carry out the printed self-assessments; then in subsequent classroom work, the teacher would review the quizzes and guide learners in deeper, homework-type projects.

For example, video that is to be viewed non-stop (non-segmented video, Figure 18) could provide an introductory overview of a topic that would be covered in more detail later. Or it could nurture affective changes, as in Domain 3 of Figure 4, with subsequent discussions.

The video-led hybrid, in which the video narration does the teaching (Figure 19), might be intended for any topic that combines practical skills and their theoretical basis, such as laboratory techniques.

The print-guided hybrid, in which printed notes interpret the video content (Figure 20), might be used for teacher-training or other topics that benefit from a preparatory observation of a master performing a skill.

9.2. Implications for teachers developing a MOOC

Learning outcomes of the print-guided hybrid (Figure 20) might interest teachers who are developing skills-training MOOCs (e.g. teacher-training).

However, a more prevalent style for MOOCs would be the video-led hybrid, in which the video narration does the teaching (Figure 19). This is because the transmissive elements of a MOOC are typically short, narrated videos interspersed with on-screen printed quizzes (Conole, 2013; Glance, 2013).

Conole (2013) notes a variety of other ingredients and characteristics that MOOCs can include. In particular MOOCs invariably include forums with peers, which ameliorate some of the limitations of transmissive media.

However, the majority of MOOC videos are "head and shoulders" lecture-capture, sometimes with a picture-in-picture view of the instructor's freehand drawing on a digital tablet (a style popularised by Khan Academy videos). More sophistication can be achieved when freehand annotations are

drawn onto printed illustrations. Yet, none of these styles use many of video's rich presentational attributes and potent pedagogic roles described in Section 3.2, neither is there a widespread use of comprehensive design principles such as those summarised in Section 3.1. In which case, not all the outcomes in Figures 19 would be achievable, because they assume that video is well-designed and its presentational attributes are fully exploited. Moreover, many MOOC video "segments" are rather lengthy—over 15 min (although occasionally this is not too long for some complex subtopics).

Regarding self-assessment in MOOCs, this is most often in the form of multiple-choice quizzes. But multiple-choice cannot include anywhere near the intensity of reflection and retrieval practice enabled by the SAQs and suggested answers in the two illustrations in this paper, Sporulation and Vietnamese Teacher Training (see Figures 14 and 17, respectively). A paucity of presentational attributes, reflective opportunities and retrieval practice would severely undermine the learning outcomes of Figures 19 and 20.

More crucially, the very fact that MOOCs are *massive* precludes the teacher's dialogic interaction with individual students.

10. Conclusion—a fertile basis for Design Research

This paper has covered many ingredients aiming to optimise and analyse the pedagogic potential of video, print and video–print hybrids.

The first set of ingredients, discussed in Section 2, were learning affordances that video and print are distinctively capable of yielding. These were later examined separately for video and print in order to surmise the learning outcomes afforded by hybrid video-print packages.

For video, the fundamental affordance, design for cognitive engagement, was the framework of pedagogic design principles, summarised in Figure 3, Section 3.1. These principles potentiate a second crucial framework, described, in Section 3.2 - the 34 potent pedagogic roles for video (Figure 4). Due attention to these two frameworks, as argued in Section 5, could achieve the learning outcomes depicted in Figure 7, categorised in terms of the *Revision of Bloom's Taxonomy of Learning Objectives*. In Section 6, these outcomes were compared with those afforded by the print medium, again in terms of the *Revised Taxonomy*. Finally came the learning outcomes afforded by three styles of video–print hybrid, all with self-assessment questions and suggested answers, illustrated in Section 7. In one type, the video is not segmented (intended to be viewed non-stop). This was compared with two styles of segmented video–print packages, one video-led (the video narration does the teaching), the other print-guided (printed notes interpret the video content). The extended learning outcomes afforded by these hybrids were discussed in Section 8, categorised in Figures 18–20, respectively.

Admittedly, much of the analysis in this paper is speculative, so judgements based on the above ingredients should be somewhat tentative. On the other hand, the analysis gleans support from five sources.

- the shoulders of the UK Open University's excellent teaching pedigree
- decades of collaboration by BBC producers with UK OU faculty in the design of videos and video-print hybrids
- planning and implementation by BBC Course Teams of 10 three-month courses on Educational TV for Development, run for overseas producers (Koumi, 2006, p. 3, 99)
- the arguments in Sections 3 and 4 concerning the potent pedagogic potential of the rich presentational attributes of non-segmented video
- the references in Sections 7.2.2 and 7.2.3 to research studies on facilitation of learning afforded by self-assessed segmentation.

This robust pedigree commends this paper's content as a fertile basis for teachers' *Design Research*. Section 9 discussed how teachers could compare their intended outcomes with the above taxonomies to determine whether the outcomes could be best advanced by video, by print or by one of the three types of video–print combination. This would be followed by producing learning materials in one or more of the media types, designed to make optimum use of their presentational attributes - and testing their efficacy.

However, a note of warning regarding the test design. In Section 8, it was argued that the degree of depth or fine detail varied between the three video–print hybrids. It was, therefore, conjectured that the Revised Bloom's Taxonomy should be augmented by adding a third dimension, *Depth*. In fact there is at least one further dimension that could be recommended. In addition to *depth*, any teacher can attest that the acquisition of knowledge, skill or motivation (i.e. *learning* in those three domains) can be **short-lived/fragile—**lacking endurance/robustness, e.g. due to low association with the learner's existing knowledge.

The implication of the two extra dimensions for Design Research is that any immediate tests of learning outcomes should be augmented by

- transfer of learning tests (to analyse depth/completeness)
- delayed tests (to analyse endurance/robustness)

Finally, a converse kind of research would be invaluable. Despite the pedigree of the paper's analysis, it rests mainly on the judgements of expert educators rather than on empirical validation. Therefore, teachers grounding their design research on the paper's analysis could at the same time conduct research into the utility and validity of the analysis itself.

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Notes

1. Skinner's teaching machines used tiny learning steps, each requiring a response, so that learners got frequent positive feedback. The UK O U used much larger learning segments with challenging self-assessment questions. As Dweck (1986) noted "frequent praise for short, easy tasks (would not) promote persistence in the face of failure" (p. 1045).
2. Note that this motivational affordance is a *proximate stimulus* for learning from the video—to be distinguished from the *sustained* affective changes addressed by Domain 3 of Figure 4.
3. Video clips illustrating some of the 34 roles in Figure 4 are described in this paper, e.g. *composite image*, listed in Section 3.2, and *amplified realism* in Section 4.2.2. The others are addressed in Koumi (2006).
4. Laurillard (1993) regards such *vicarious experiences* (e.g. viewpoints, places, staged events) as being a "logistical delivery roles for video, whereas given enough resources, the students would engage in these experiences directly" (p.114). However, logistic delivery can be indispensable. There will never be enough resources (or permissions) to take every cohort of students to far-flung or dangerous locations and supply them with powerful telescopes, helicopters, or bathyspheres.
5. Regarding realism, the type of sound track recommended in item 1 of Domain 2 is crucial. To capture the realism of the recorded event, the *location sound* should be recorded synchronously (the sounds made by objects and people: *sync sound*).
6. See Koumi (2013a) for a project in which video demonstrated language skills (function 4.5 of Figure 4), and in which the 56 videos closely adhered to the design principles in Koumi (2006).
7. Incidentally, the answer for question 11 suggests that the discovery of penicillin's effect was the result of a misinterpretation by Fleming, following a careless procedure!

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Appendix A

Figure 21. Revision of Bloom's Taxonomy of Learning Objectives: in full (Krathwohl, 2002).

	A. Factual knowledge a. terminology b. details	**B. Conceptual knowledge** a. classifications b. principles c. theories	**C. Procedural knowledge** a. skills or algorithms b. techniques/method c. criteria for using procedures	**D. Meta-cognitive knowledge** a. learning strategies b. task-specific strategies c. self-knowledge
1. Remember				
1.1. Recognition				
1.2. Recalling				
2. Understand				
2.1. Interpreting				
2.2. Exemplifying				
2.3. Classifying				
2.4. Summarizing				
2.5. Inferring				
2.6. Comparing				
2.7. Explaining				
3. Apply				
3.1. Executing				
3.2. Implementing				
4. Analyze				
4.1 Differentiating				
4.2. Organizing				
4.3. Attributing				
5. Evaluate				
5.1. Checking				
5.2. Critiquing				
6. Create				
6.1. Generate				
6.2. Plan (design)				
6.3. Produce				

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