



025S

# The Impact of Productive Failure on Learning Performance and Cognitive Load

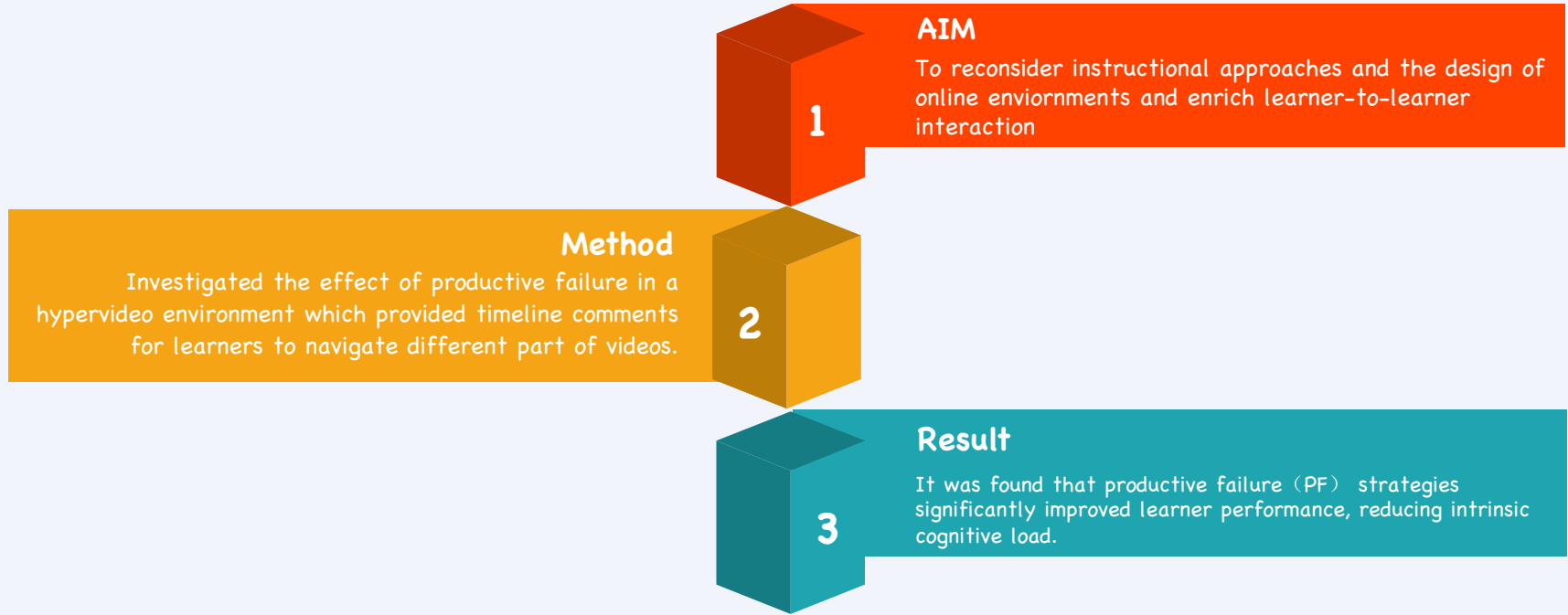
—Using Hypervideo to Facilitate Online Interactions

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# ABSTRACT



# Why in Hypervideo?



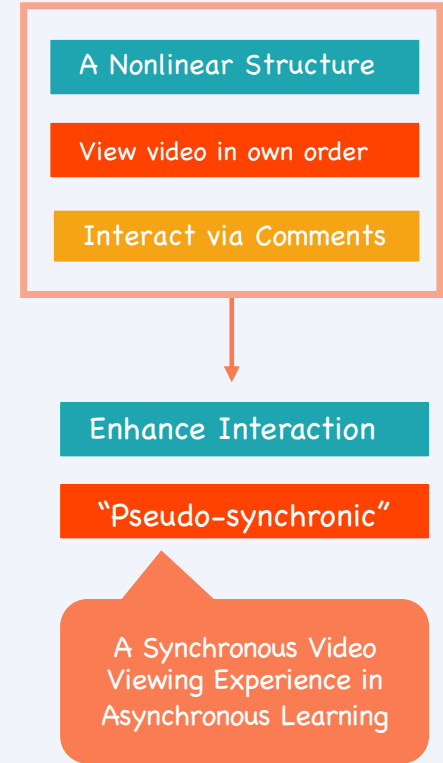
Enhance learner-to-learner interactions



Hypervideo: form of hypermedia that creates a nonlinear structure for streamlining videos.



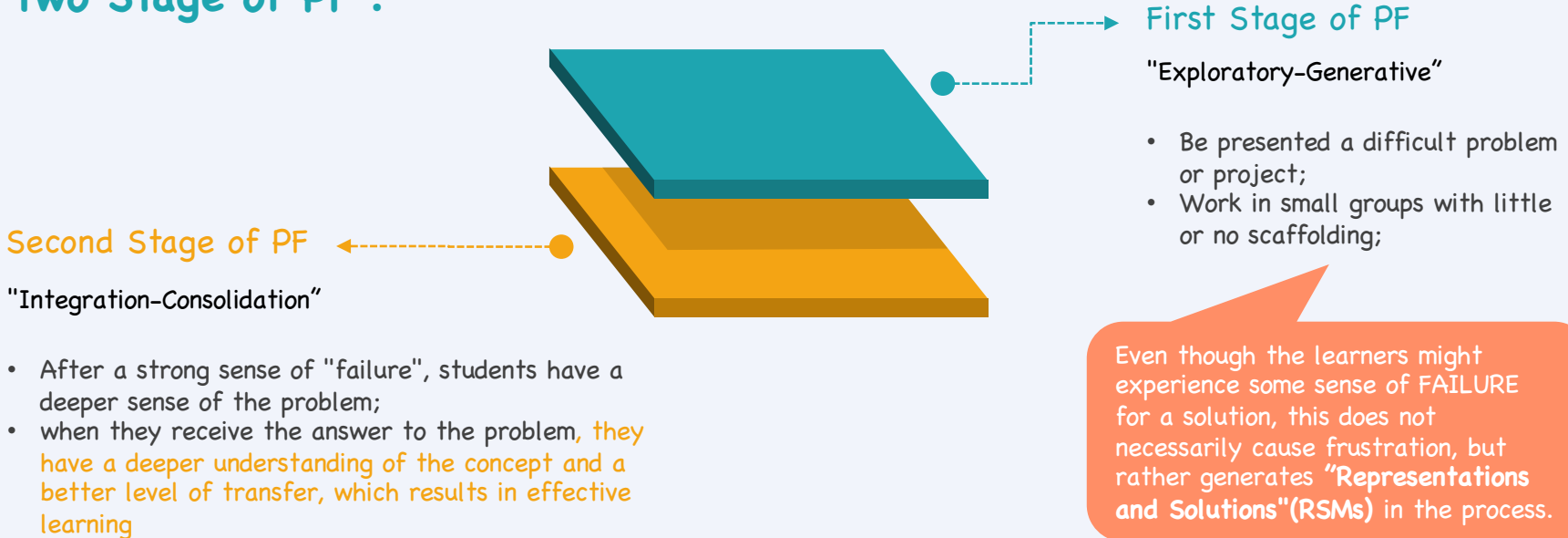
Learners can view videos in different orders, and to interact with others via comments.



# Productive Failure Theory (PF)

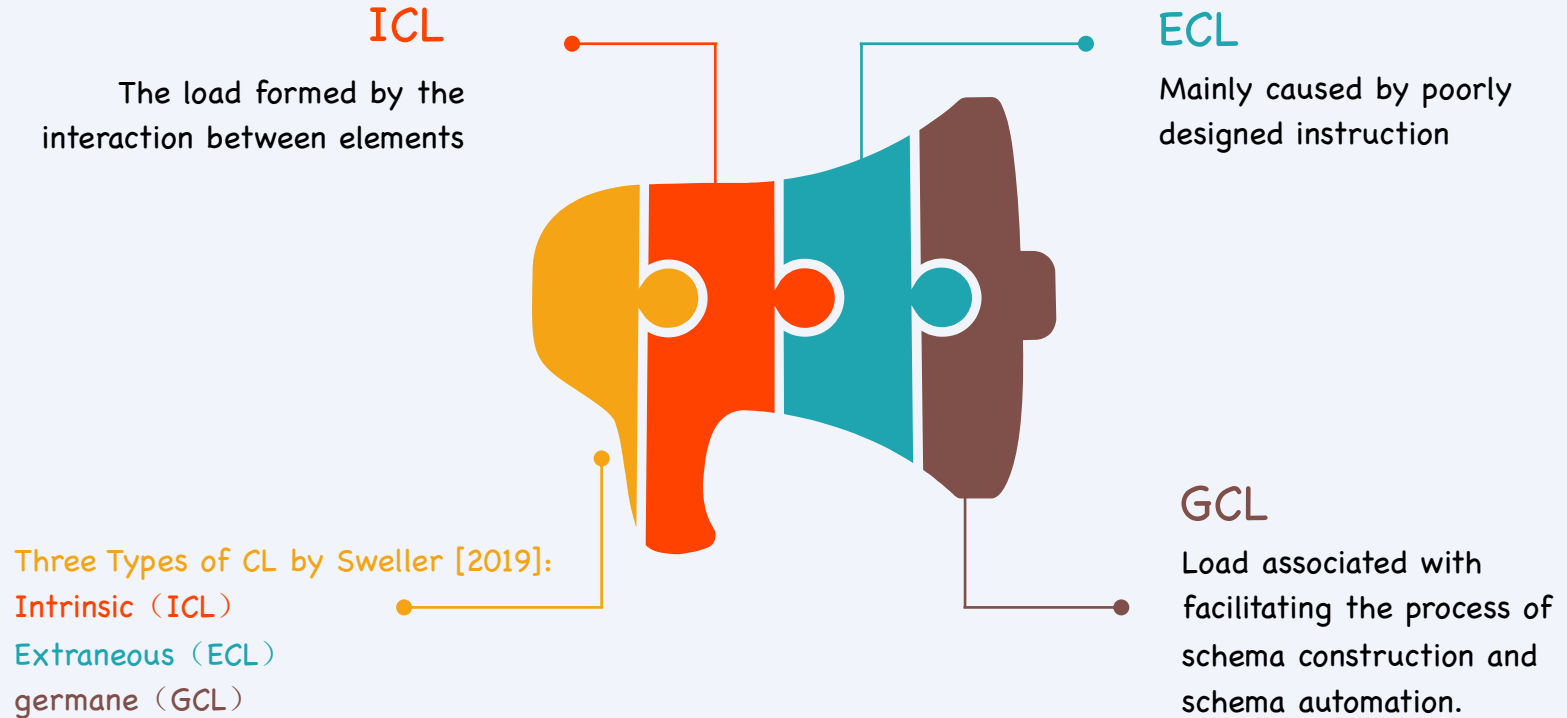
Kapur(2008): *Experiencing some failure in the early stages of problem solving helps students to learn more effectively*;  
Loibl and Rummel(2014): *Productive failure theory is most effective for problem-solving learning and has been shown to be particularly applicable in mathematics and science courses.*

## Two Stage of PF :



# Cognitive Load

A hypertext online learning environment can create additional cognitive demands on learners [2000]



# Method : Participants & Platform

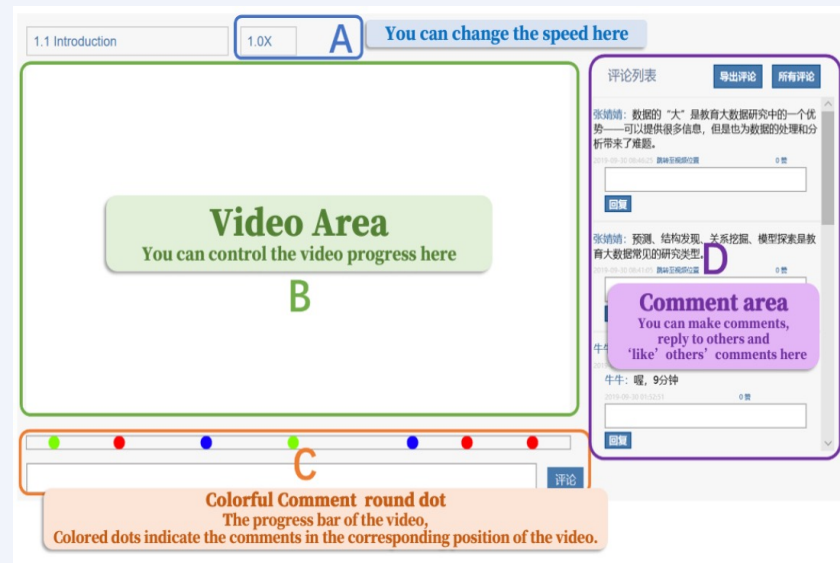
## Participants

TABLE I. DEMOGRAPHIC CHARACTERISTICS OF EFFECTIVE PARTICIPANTS IN TERMS OF GENDER, PROFESSIONAL BACKGROUND

	Group PF	Group DI
<b>Gender</b>		
Male	15 (68.9%)	11 (57.9%)
Female	7 (31.8%)	8 (42.1%)
Sum	22	19
<b>Academic Background</b>		
Mathematics, Statistics, Finance	7 (31.8%)	4 (21.05%)
Management	4 (18.2%)	4 (21.05%)
Physics, Astronomy	4 (18.2%)	3 (15.79%)
Pedagogy, Psychology	3 (13.6%)	4 (21.05%)
Computer Science and Technology	2 (9.1%)	2 (10.53%)
Biological, Geographical	2 (9.1%)	2 (10.53%)
Sum	22	19

*The participants were either sophomores, juniors, or seniors, in different educational backgrounds.*

## Platform



*Allow learners to post or reply to video-tagged comments. Offers hyperlinks for other learners to identify the parts of videos watched along the timeline. Developed by JAVA and PHP.*

# Method : Materials & Experimental Conditions

## Video

Three videos about «*Big Data in Education*»

1.1 Introduction

1.2 Prediction

1.3 Classification Part 1

Each part about 10 min.

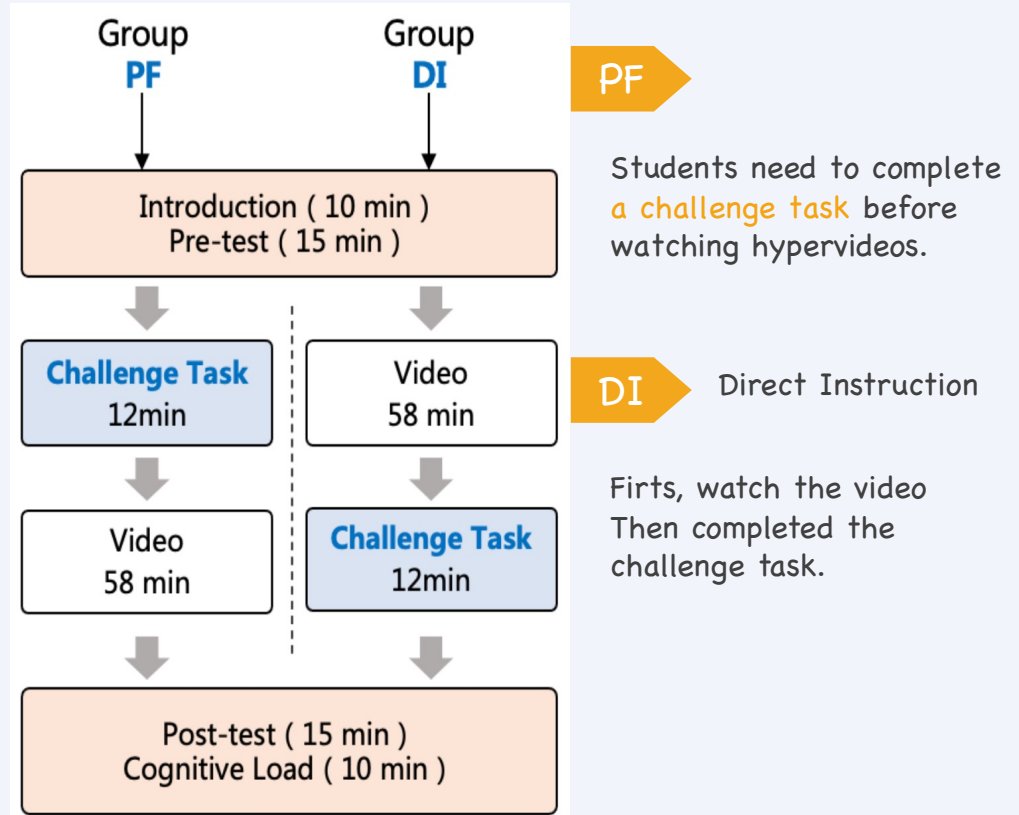
## Pre-Test

2 single-choice, 2 fill-in-the-blank  
Test the prior knowledge.

## Post-Test

- Four questions to test knowledge gained during the experimentation;
- Cognitive scales including 22 questions in total to measure the cognitive load.

\* Reliability of CL:  $ICL-\alpha = 0.86$ ,  $ECL-\alpha = 0.80$ ,  $GCL-\alpha = 0.80$



# Result

## Challenge Task

Independent sample T-Test showed **no significant** difference between PF and DI. But mean score of PF (M=3.36) is **slightly lower** than DI(M=3.77).

## Pre and Post Test

Independent sample T-Test showed **no significant** difference between tests in PF and DI.

## Pre and Post Test in PF

*Significantly higher*

## Pre and Post Test in DI

*No significant*

TABLE II. DIFFERENCES IN PRE AND POST TEST SCORES BETWEEN THE PRODUCTIVE FAILURE GROUP AND THE DIRECT INSTRUCTION GROUP

<i>Group</i>	<i>N</i>	<i>Pre-Test</i>	<i>Post-Test</i>	<i>t</i>	<i>Sig</i>
PF	22	3.41	3.77	-2.592	<b>0.017<sup>a</sup></b>
DI	19	3.37	3.58	-1.455	0.163

<sup>a</sup>. p is significant at the level of 0.05

## Cognitive Load

ICL *was significantly lower* in PF than DI

TABLE III. DIFFERENCES IN PRE AND POST TEST SCORES BETWEEN THE PRODUCTIVE FAILURE GROUP AND THE DIRECT INSTRUCTION GROUP

	<i>Group</i>	<i>N</i>	<i>M±SD</i>	<i>Standard error value</i>	<i>t</i>	<i>Sig</i>
<i>ICL</i>	PF	22	4.417±1.358	0.538	-0.794	<b>0.048<sup>b</sup></b>
	DI	19	4.844±0.719			
<i>ECL</i>	PF	22	3.673±1.124	0.371	-1.11	0.274
	DI	19	4.084±1.250			
<i>GCL</i>	PF	22	4.065±0.706	0.252	0.497	0.622
	DI	19	3.940±0.904			

<sup>b</sup>. p is significant at the level of 0.05



# Disucssion

**Failure is also “productive” and "effective" in online enviorments.**

Although the learners using productive failure to teach did not perform well on the challenge task, they showed a significant increase in the subsequent post-test

**Learners using productive failure seemed to perceive less intrinsic load**

The challenge task helped them to activate their prior knowledge while being the first to complete the task, and thus they felt relatively less psychologically taxed when watching and interacting with the videos.

**Limitaion**

The learners who seleted this course were interested in big data in education, thus **minimizing the effect of motivation;**

**The sample size of the present study was modest.**



# Log Data Analysis for Attention Flow but not in Paper

Ten types of behavioral data were recorded according to the research needs

1 Playing a video

6 Replying to a comment

2 Pausing a video

7 Liking a comment

3 Video skipping  
(Jumping from one point in a video to another)

8 Clicking on the corresponding red dot generated by a comment

4 Video dragging  
(dragging from one point in a video to another)

9 Clicking on the timestamp of a comment  
Jump to the location of the comment

5 Posting a comment

10 Choose to watch a certain video

# Log Data Analysis for Attention Flow but not in Paper

Record the Log Data when Users **Clicking to jump into Different Video Units**

## Attention Flow Network

A:  $1 \rightarrow 3 \rightarrow 5 \rightarrow 6$

B:  $1 \rightarrow 4 \rightarrow 2 \rightarrow 3 \rightarrow 4$

C:  $3 \rightarrow 5 \rightarrow 4 \rightarrow 2 \rightarrow 5 \rightarrow 3 \rightarrow 1 \dots\dots$

Divide each instructional video into **50 video units** of equal length according to the video length



Each video unit **is a small piece of meaningful learning content** as a node in the attention stream network

**A, B, C** : Three different **Users**

**Number**: **Different Video Units**

**1→3** : A resource node 1 to resource node 3 to establish a directed edge

All users 1→3 click jump are recorded, calculate the number of all users 1→3 click jump (i.e., the weight of the directed edge 1→3)

TABLE II. SCHEMATIC REPRESENTATION OF THE COLLECTIVE ATTENTION FLOW NETWORK MATRIX

	Source	1	2	3	4	5	6	Sink
Source		2		1				
1				1	1			1
2				1		1		
3		1			1	2		
4			2					1
5				1	1		1	
6								1
Sink								

**Source**: User's attention jumped from the outside world to the Internet resource

**Sink** : User's attention shifted from the Internet resource node to the outside world

# Log Data Analysis for Attention Flow but not in Paper

The definition and expressions of **the circulation flow, input flow, and dissipation flow** in the flow network

## Inflow of collective attention

The flow of learners' attention to learning content node  $i$  at the first time after entering the online learning environment  $I_i = f_{0,i}$

## Dissipation of collective attention

Learner's attention is not transferred from learning content node  $i$  to the next node  $j$ , but to the external space outside the learning content, that is, to the flow of the sink node  $D_i = f_{i,N+1}$

## Circulation of collective attention

Learner's attention is transferred from learning content node  $i$  to the next node  $j$ , that is  $f_{i,j}$

Each instructional video was divided into 50 video units. 3 videos in total, means that there are  $3 \times 50 = 150$  video units or 150 nodes of the streaming network in the whole video course.

TABLE V. DIFFERENCES IN ATTENTIONAL FLOW BETWEEN THE PRODUCTIVE FAILURE GROUP AND THE DIRECT INSTRUCTION GROUP

	<i>Group</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>Sig</i>
<i>Inflow</i>	PF	0.0067	0.0064	0.000	149	1.000
	DI	0.0067	0.0063			
<i>Circulation</i>	PF	0.102	0.160	-3.503	149	0.001**
	DI	0.134	0.149			
<i>dissipation</i>	PF	0.0067	0.0022	0.000	149	1.000
	DI	0.0067	0.0019			

<sup>c</sup>: p is significant at the level of 0.001

Circulation flow of learners in PF instructional sequence group is smaller than the per capita circulation flow of learners in the DI sequence group. **(Need more future work)**

A decorative border of various colorful books surrounds the central text. The books are in shades of orange, teal, brown, and yellow, some open and some closed, arranged in a circular pattern around the center.

# Thank you for Listening

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