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Investigating product-oriented versus process-oriented worked examples to support understanding of quality teaching principles.

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- Worked examples are an effective instructional means to teach complex problem solving skills.
- It has been argued that worked examples decrease extraneous load, enabling **more** Working Memory resources to be directed to activities that facilitate learning and transfer performance.

Paas and Van Gog (2006)



# Worked Examples in a Well Structured Environment

## Product-Oriented

Given  $2x + 1 = 11$ , solve for  $x$ .

$$2x + 1 = 11$$

$$2x = 10$$

$$x = 5$$

## Process-Oriented

Given  $2x + 1 = 11$ , solve for  $x$ .

$$2x + 1 = 11$$

Subtract 1 from both sides

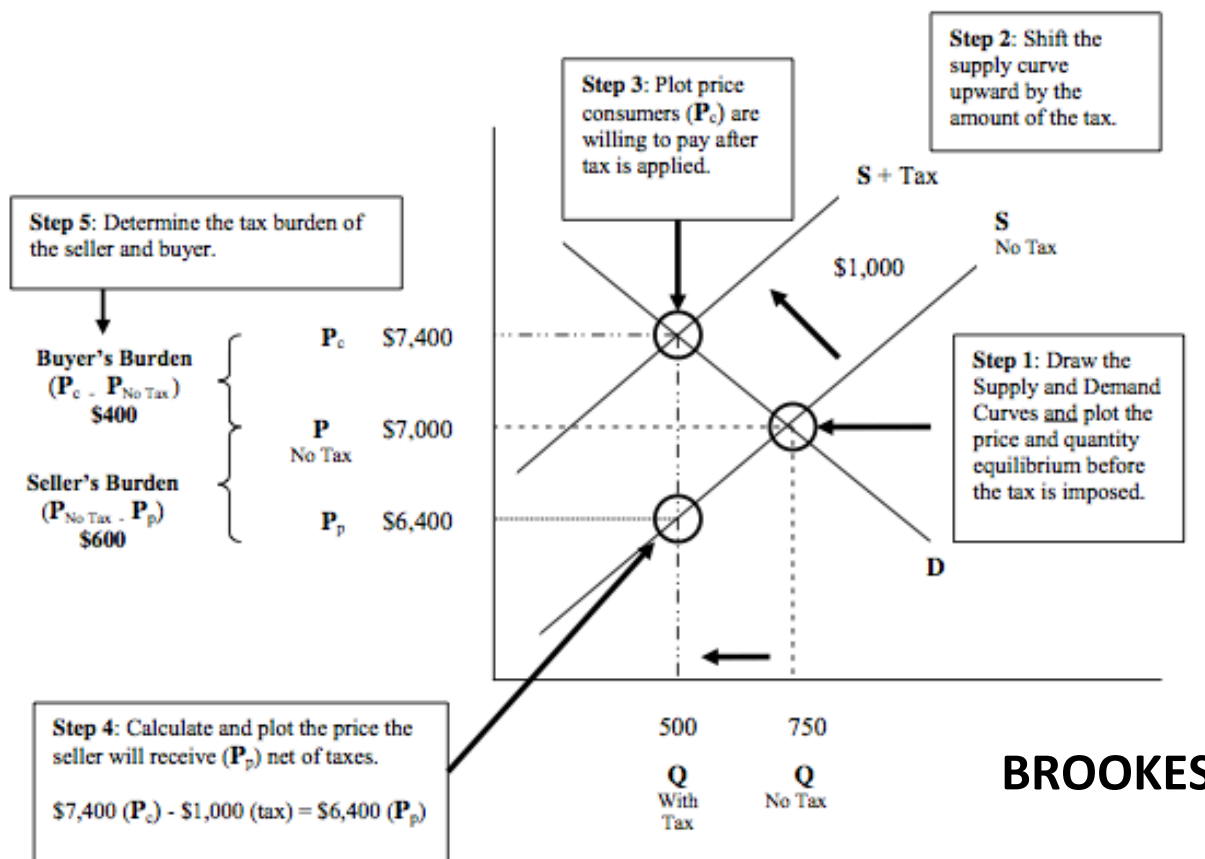
$$2x = 10$$

Divide by sides by 2

$$x = 5$$

# Product-Oriented Worked Examples

“Effects of process-oriented and product-oriented worked examples and prior knowledge on learner problem solving and attitude: A study in the domain of microeconomics”. Brooks



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# Process-Oriented Worked Examples

“Effects of process-oriented and product-oriented worked examples and prior knowledge on learner problem solving and attitude: A study in the domain of microeconomics”. Brooks

**Step 5:** Determine the tax burden of the seller and buyer. Remember, the actual burden of a tax (or share of the burden) does not depend on whether the tax is statutorily placed on the seller or the buyer. The supply and demand elasticity determines how the tax is distributed between the buyer and seller. Because the increase in price drastically affects the quantity demanded, the seller must absorb a larger portion of the tax burden.

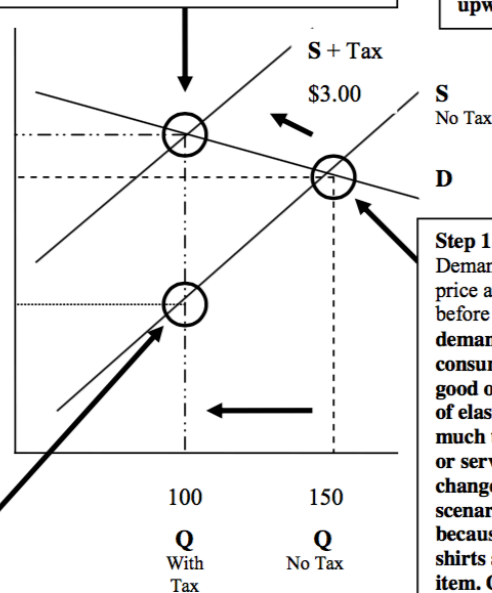
Buyer's Burden ( $P_c - P_{No\ Tax}$ ) \$1.00	{	$P_c$	\$21.00
		$P$ No Tax	\$20.00
Seller's Burden ( $P_{No\ Tax} - P_p$ ) \$2.00	{	$P_p$	\$18.00

**Step 4:** Calculate and plot the price the seller will receive ( $P_p$ ) net of taxes.

$$\$21.00 (P_c) - \$3.00 (\text{tax}) = \$18.00 (P_p)$$

This point represents the price the seller receives after adjusting the price due to the tax. Prior to the tax, the original price for a t-shirt was \$20.

**Step 3:** Plot price consumers ( $P_c$ ) are willing to pay after tax is applied. The new equilibrium price represents the seller's and buyer's acceptance of a portion of the tax burden. When demand is elastic the consumer is not willing to purchase a good when price increases.



**Step 2:** Shift the supply curve upward. A tax imposed on the seller causes the supply curve to shift upward.

**Step 1:** Draw the Supply and Demand Curves and plot the price and quantity equilibrium before the tax is imposed. The demand curve represents consumer demand for a good or service. The concept of elasticity determines how much the quantity of a good or service responds to a change in price. In this scenario, the good is elastic because consumers view t-shirts as a non-essential item. Consequently, price changes have a greater influence on consumer demand.

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# Ill-Structured v Well-Structured



**Ill-structured  
Environment**

**Well-structured  
Environment**



# NSW Quality Teaching Model

Intellectual Quality	Quality Learning Environment	Significance
Deep Knowledge	Explicit Quality Criteria	Background Knowledge
Deep Understanding	Engagement	Cultural Knowledge
Problematic Knowledge	High Expectations	Knowledge Integration
Higher-order Thinking	Social Support	Inclusivity
Metalanguage	Students' Self-regulation	Connectedness
Substantive Communication	Student Direction	Narrative



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# Coding Substantive Communication

1	Almost no substantive communication occurs during the lesson.
2	Substantive communication among students and/or between teacher and students occurs briefly.
3	Substantive communication among students and/or between involves at least two sustained interactions.
4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.
5	Substantive communication, with sustained interactions, occurs throughout the lesson, with teachers and/or students scaffolding the communication.



# Research Question

What form of Worked Example best supports pre-service teachers' understanding and application of the NSW Quality Teaching Model when:

- (a) coding elements
- (b) applying Knowledge



# Participants

**Experiment 1: 1<sup>st</sup> Year, 1<sup>st</sup> Semester**  
**Master of Teaching Pre-Service Teachers**

**Experiment 2: 2<sup>nd</sup> Year, 2<sup>nd</sup> Semester**  
**Master of Teaching Pre-Service Teachers**

## Three Conditions

**Control**

**Product**  
**(Steps to solution)**

**Process**  
**(Steps to solution and reasons provided)**



# Methodology

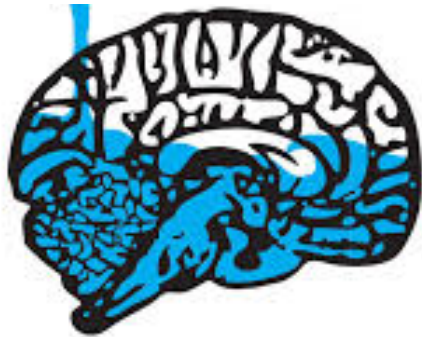
Introductory Phase	<ul style="list-style-type: none"><li>• Introduction: Mental Effort Rating</li><li>• Introduction to the Quality Teaching Model (QTM) – focus on Substantive Communication</li><li>• Information on Coding of QTM</li></ul>
Learning Phase	<ul style="list-style-type: none"><li>• Two Worked Examples</li><li>• Mental Effort Rating</li><li>• Difficulty rating</li></ul>
Test Phases	<ul style="list-style-type: none"><li>• Tasks – 1 recall, 6 Near Transfer &amp; 4 Far Transfer</li><li>• Mental Effort Rating</li><li>• Difficulty Rating</li></ul>



# Hypothesis



Ill-structured domain



Low prior knowledge

Process & Product  
Worked Example

>

Conventional  
(Control)



Understanding



Application



Load



# Hypothesis



Ill-structured domain



Low prior knowledge

Process  
Worked Example  
>  
Product  
Worked Example



Understanding



Application



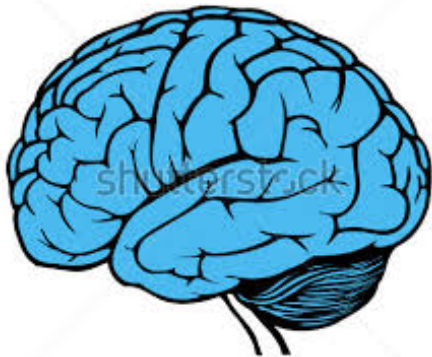
Load



# Hypothesis



Ill-structured domain



High prior knowledge



Conventional  
(Control)  
and  
Product Worked  
Example  
>  
Process Worked Example



Understanding



Application



Load



# Control Group

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive Communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversations.	Sustained Interactions  Focus on the Substance of the lesson  Interaction is Reciprocal

Coding Score

Generic  
description  
of the  
Coding Score

Characteristics





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Coding Score

Generic  
description  
of the  
Coding Score

Characteristics



# Product-Oriented Worked Example Condition

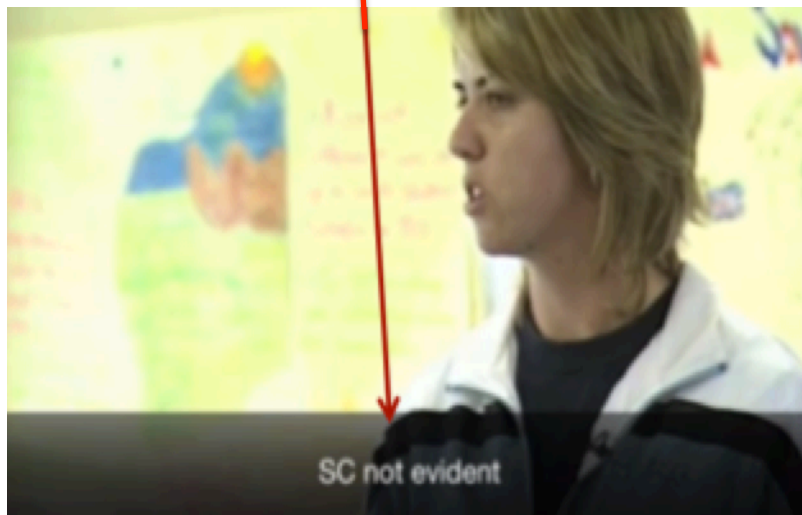
Annotations indicating whether SC is evident of not evident.

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive Communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversations.	<b>Sustained Interactions</b> Sustained interactions were evident  <b>Focus on the Substance of the lesson</b> Focus on the substance of the lesson was high  <b>Interaction is Reciprocal</b> Reciprocal interactions were evident

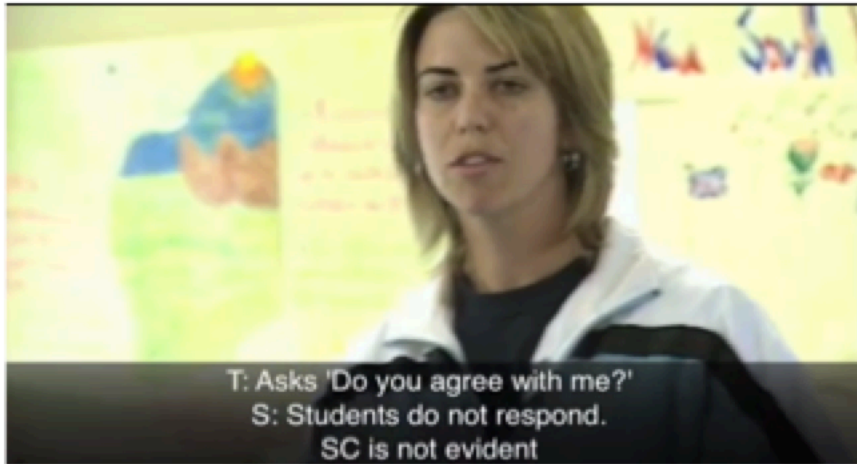
Coding Score

Generic description of the Coding Score

Characteristics



# Process-Oriented Worked Example Condition



Annotations on the video  
lesson recording  
indicating the reasons as  
to whether SC is evident  
or not evident

ELEMENT	Coding Score	Generic Coding Description	The Coding Score was determined by the level of:
Substantive communication	4	Substantive communication, with sustained interactions, occurs over approximately half the lesson with teacher and/or students scaffolding the conversation.	<p><b>Sustained Interactions</b></p> <p>In the lesson, several sustained interactions were evident. The teacher asked questions like "anything else?" to encourage students to extend their responses which continued the idea beyond the simple 'initiate-respond-evaluate' (IRE) pattern. The group work showed students effectively building a shared understanding.</p> <p><b>Focus on the Substance of the lesson</b></p> <p>The communication moved beyond mere recounting of facts and experiences and encouraged the application of ideas. The teacher raised questions like "what things at parties might concern you?" to enable the students to apply ideas and make distinctions focusing on the substance of the lesson.</p> <p><b>Reciprocal Interaction</b></p> <p>The lesson wasn't scored a 5 as the introduction of the lesson involved Initiate-Respond-Evaluate communication, where the teacher asked routine questions and students provided short answers. An example of a high level of reciprocal interaction includes the teacher asking the students 'do you agree with me?' to which there was no response. During the group work, reciprocal interactions are high as the flow of information and ideas is at least two ways in direction.</p>

Characteristics



# Recall Task

## Task 3 (1 minute to complete)

List the three characteristics of Substantive Communication:

1.

2,

3.



# Near-Transfer Task

## Task 5 (2.5 minutes to complete)

You will now watch a video of a History lesson.

Circle your Coding Score for the element of Substantive Communication in the table below.

1	2	3	4	5
Almost no Substantive Communication occurs				Substantive Communication occurs throughout the lesson

Using evidence from the video, justify your score.

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# Far Transfer Task

## Task 7 (3 minutes to complete)

You will watch a video of a science lesson.

Suppose you were the teacher, how would you enhance the characteristics of Substantive Communication listed below?

Characteristics	Strategies to enhance Substantive Communication
There is sustained interaction.	
There is a focus on the substance of the lesson.	
The interaction is reciprocal.	



Rate the amount of mental effort you invested to complete Task 1. Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely low Mental Effort				Neither low nor high Mental Effort				Extremely high Mental Effort

Rate how difficult the task was for you. Circle your rating.

1	2	3	4	5	6	7	8	9
Extremely easy				Neither easy nor difficult				Extremely difficult





# Preliminary Results

Task	Control (n=10)	Product (n=18)	Process (n=27)
Mental Effort	4.83	4.44	4.69
Difficulty	4.7	3.44	3.73
Recall Tasks (3 Marks)	1.15	0.83	1.31
Near Transfer (12 Marks)	6.4	6.03	7.48
Far Transfer (7 Marks)	1.95	2.85	2.60

2 Worked Examples – 5 Tasks

# Preliminary Results – Mental Effort & Task Difficulty

Task	Control (n=10)	Product (n=18)	Process (n=27)
Worked Examples MER	3.2	2.6	2.8
Worked Examples TD	2.9	1.8	1.8
Recall Task MER	5.1	3.4	5.3
Recall Task TD	5.1	5.6	5.4
Near Transfer MER	5.2	5.1	5.3
Near Transfer TD	5.1	3.9	3.9
Far Transfer MER	6.6	5.6	6.2
Far Transfer TD	6.5	5.4	5.5

# Where to now?

- Analysis
- Experiment 2 – Experts scheduled October 2016
- Challenges



# Thank You for Listening

Further information:

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