

## DESIGN OF INSTRUCTIONAL MATERIALS FOR TEACHING AND LEARNING PURPOSES: THEORY INTO PRACTICE

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**Abstrak:** Reka bentuk pengajaran merupakan pembinaan spesifikasi pengajaran yang sistematik dengan menggunakan teori pengajaran dan pembelajaran untuk menjamin mutu pengajaran. Ia merupakan satu proses menyeluruh yang menganalisis keperluan dan matlamat serta perkembangan sistem penyampaian untuk memenuhi kesemua keperluan tersebut. Reka bentuk pengajaran meliputi pembinaan bahan pengajaran, aktiviti, percubaan dan penilaian keseluruhan pengajaran dan aktiviti pelajar. Perlu ditegaskan juga bahawa rekabentuk dan pembinaan pengajaran dan pembelajaran mesti mengambil kira aspek pedagogi, teori pembelajaran, teori rekabentuk pengajaran dan model serta media dan teknologi yang akan digunakan. Justeru, reka bentuk pengajaran berperanan sebagai jambatan konsep di antara pedagogi, teori pembelajaran, reka bentuk pengajaran dan saluran yang digunakan. Namun, sejauh manakah pengajar mempraktik teori berkenaan dalam pengajaran? Kertas ini akan membincangkan berkaitan teori rekabentuk pengajaran, teori pembelajaran, dan model reka bentuk pengajaran serta implikasinya terhadap rekabentuk bahan pengajaran yang efektif untuk kegunaan pengajaran dan pembelajaran. Perbincangan ini melibatkan contoh-contoh teori reka bentuk pengajaran dan model tertentu yang dapat dimanfaatkan.

### INTRODUCTION

The emerging needs of the information age require a new paradigm for the field of instructional design (Reigeluth, 1996). It must be borne in mind that the design and development of instructional materials for teaching and learning purpose must take into consideration important aspects such as pedagogy, learning theories, ID theories and models and the media employed. As with other fields, the discipline of instructional design has evolved in tandem with paradigm changes in learning and instruction theories. In the 60's and 80's the design of instruction were more prone towards behaviorism and cognitivism. However with the emergence of computer technologies, the constructivist perspectives in teaching and learning seemed easier to be implemented. This is because computer technology is able to support many of the principles of constructivist learning. Although the field of instructional design has evolved greatly, it would be meaningless if these theories are ignored or even worst not practiced by the practitioners.

### WHAT IS INSTRUCTIONAL DESIGN?

Montague, Wulfrek and Ellis (1983) highlighted that the best design does not compensate for the lack of skills needed to develop quality instruction. An instruction is a set of events that facilitate learning whilst design means a creative pattern or a rational, logical, sequential process intended to solve problems. Thus, instructional design can be defined as "the systematic process of translating principles of learning and instruction into plans for instructional materials and activities". However, there are many different definitions for instructional design and all of them are an expression of underlying philosophies and view points of what is involved in the learning process (Siemens, 2002). According to Albion et al., instructional design can be defined as a process, a discipline, a science, or reality as below:

*Instructional Design as a Process:* ID is the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. It is the entire process of analysis of learning needs and goals and the development of a delivery system to meet those needs. It includes development of instructional materials and activities and try-out and evaluation of all instruction and learner activities.

*Instructional Design as a Discipline:* ID is that branch of knowledge concerned with research and theory about instructional strategies and the process for developing and implementing those strategies.

*Instructional Design as a Science:* ID is the science of creating detailed specifications for the development, implementation, evaluation and maintenance of situations that facilitate the learning of both large and small units of subject matter at levels of complexity.

*Instructional Design as Reality:* ID can start at any point in the design process. Often a glimmer of an idea is developed to give the core of an instruction situation. By the time the entire process is done the designer looks back and she or he checks so that all parts of the 'science' have been taken into account. Then the entire process is written up as if it occurred in a systematic fashion.

However, all of them share some basic features as follows (Thompson, 2001):

- Needs assessment
- Goal and objective identification
- Audience and setting analysis
- Content and delivery development
- Evaluation

The greatest objective of ID is to serve the learning needs and success of students through effective presentation of content and fostering of interaction. Thus, a systematic process of Instructional Design enables an educator or instructor to:

- Identify the performance problem
- Determine the goals and objectives
- Define your learners and their needs
- Develop strategies to meet needs and goals
- Assess learning outcomes
- Evaluate if goals, objectives and needs are met

## **INSTRUCTIONAL DESIGN THEORIES AND MODELS**

Most instructional design theories and models rely on a set of steps to produce an effective result (Hannafin & Peck, 1988). Their features generally include stages for planning, development, and testing. In more abstract terms an instructional design model is a kind of abstract design rule for a given instructional design approach or a given pedagogic strategy. Here is an overview of some different theories and models for ID:

- R. M. Gagne's Instructional Design Theory
- C. M. Reigeluth's Instructional Design Theory
- M. D. Merrill's Instructional Design Theory
- D. H. Jonassen's Instructional Design Theory
- Dick & Carey Model
- Hannafin & Peck Model
- ASSURE Model

- Knirk & Gustafson Model
- Jerrold Kemp Model
- Gerlach-Ely Model
- Rapid Prototyping Model
- USAF Model
- Gagne-Briggs Model
- ADDIE as the General Model

Why do we need the instructional theories and models when we design an instructional material? According to Thompson (2001), instructional theories and models will guide us as follows:

- Speed up the process - focusing the team and serve as foundation of project development
- Assist in communication: Team members need to share expertise, intent, calendars, and so forth. By using ID Models, each of team member will know when and what to give or share with the other team member
- Cover all phases of good instructional design: make sure that all elements of instruction are include, relate to and support each other.

There are two main differences between ID models, which are physical differences and content differences. The physical difference focuses on form and phase whilst the content differences focuses on characteristics, functions and typology. Commonly, there are three types of ID models forms namely vertical, circular and horizontal. Table 1 shows the differences between some of the ID models based on their phases.

**Table 1: Differences between Some of the ID Models Based On Their Phases**

<b>ID MODELS</b>	<b>PHASES</b>
Dick & Carey	8
Hannafin & Peck Model	3
ASSURE Model	6
Waterfall	6
Knirk & Gustafson Model	3
Jerrold Kemp Model	9
Gerlach-Ely Model	4
Rapid Prototyping Model	4
USAF Model	5
Gagne-Briggs Model	4
ADDIE Model	5

According to Gustafson and Branch (2002), the differences between some of the ID models based on their characteristics of content are shown in Table 2.

**Table 2: Differences between ID Models Based On Their Characteristics of Content**

ID MODELS	CHARACTERISTICS OF THE CONTENT
ADDIE	A general purpose model, most useful for creating instructional products, but also applicable for program design.
Dick & Carey	Exemplifies the systematic approach to curriculum and program design; applicable across a range of context areas (e.g., K-12 to business to government) and users (novice to expert); a learner-centered model.
Hannafin & Peck	Simple but elegant in the way in which all three phases are connected to "evaluate and revise".
ASSURE	This model assumes that instruction will not be delivered using lecture/text book only. It allows for the possibility of incorporating out-of-class resources and technology into the course materials.
Knirk & Gustafson	A small scale model that can be used for individual lessons or units; the model is simple in its design but inclusive of details and tries to convey this inclusiveness through circles and arrows.
Jerrold Kemp	Most useful for large-scale programs involving groups of people and multiple resources; focus on content analysis
Gerlach-Ely	Well suited to K-12 and higher education
Rapid Prototyping	Useful for large-scale or projects; it allows for better communication between the designer and users because the needs are clearly expressed from the beginning; its non-linear approach allows for more flexibility in the instruction and can catch problems early in the development stages
Gagne & Briggs	Model is adapted to Web Based Instruction; categorize learning outcomes; organize instructional events for each kind of leaning outcome

Gustafson and Branch (2002), functions of content differences among the ID models are classified into three types, which are classroom, product and system. For the typology contents difference, DSchneider believes that the term instructional design model is overloaded with various meanings. He suggests that we can find at least six kinds (at least for now):

- Models that describe a pedagogic strategy in detail. Examples: Nine events of instruction (behaviorist/cognitivist), inquiry-based learning (constructivist)
- Models that relate to the quality of a design. Example: Merrill’s First principles of instruction
- Models that provide a method to create a design: See instructional design method. Example: Instructional systems design models like ADDIE. There exist sub models for things like defining goals, analyzing a domain of knowledge, evaluation, etc.
- Complementary models that will enhance a design. Examples: Self-regulated strategy development model (strategy development), Felder design model (learning styles)
- Change management related models that specifically address the issue of introducing new pedagogic and associated instructional design models. Example activity theory-based expanded learning.
- Models that describe the functions of a learning environment. The Sandberg learning environment functions

## LEARNING THEORIES

Learning theories describe how people and animals learn, thereby helping us understand the inherently complex process of learning. Basically there are three main perspectives in learning theories: behaviorism, cognitive, and constructivism. Table 3 showed the principle and characteristic whilst Table 4 summarizes the strengths and weaknesses of these three learning theories.

**Table 3: Principle and Characteristic of Main Perspectives in Learning Theories**

<b>Learning Theories</b>	<b>Principle and Characteristic</b>
Behaviorism	Learning occurs when there are changes in behavior that can be measured. Did not consider the thinking behind the behavior. Emphasizes on stimulus and response. Supports mastery learning. Suited for low-order thinking (LOTS).
Cognitive	Thinking process behind the behavior; emphasizes what is in their mind. Organization of knowledge in the brain, how knowledge and information is stored and retrieved.
Constructivism	Each individual has his/her own mental framework via their experience. Learning occurs when there is disequilibrium between new knowledge and prior knowledge. Suited for higher order thinking (HOTS)

**Table 4: The Strengths and Weaknesses of Learning Theories**

<b>Learning Theories</b>	<b>Strengths</b>	<b>Weaknesses</b>
Behaviorism	Student focuses to the information and can react on the information.	No suitable stimulus for the response
Cognitive	Train for one method and enhance consistencies	Student learn through one method which may not be the best
Constructivism	Student interpret reality in different form	No wrong answers. Each student has his/her own different mental model

## THEORY INTO PRACTICE

Most instructors/teachers/educators are probably aware of the learning theories, ID theories and ID models. But do we put theory into practice? Are we ID practitioners? If so do we practice the basic phases in the simplest ID model (say the ADDIE Model): analyze, design, develop, implement, evaluate while designing teaching and learning materials for our instruction?

The table below (Table 5) gave some preliminary research data among some IPTA instructors' practice of ID in designing instruction (total samples = 23). The result indicated more than 50% of IPTA instructors were uncertain about their ID practice. About 30.43% agree that they do practice ID while about 10.13% agree that they do not know about ID. For understanding ID concept, the majority of the instructors (65.2%) did not quite understand ID models and theories, only 13% have some ideas of ID concept. However, the majority of them did evaluate their instruction but 100% of them were not sure about the design of their instruction.

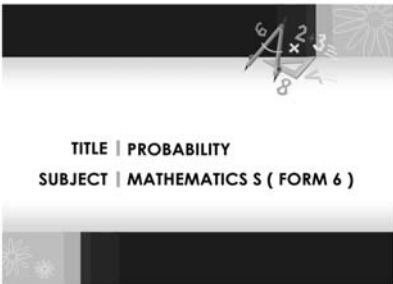
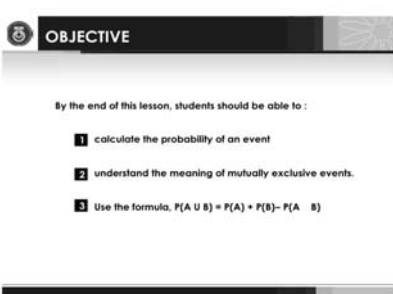
**Table 5: ID Practice among Some IPTA Instructors**







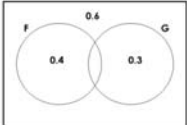
	Disagree		Not Certain		Agree	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
<b>ID Concept Understanding</b>	5	21.7	15	65.2	3	13.0
<b>Analyze</b>	1	4.3	10	43.5	12	52.2
<b>Design</b>	0	0	23	100.0	0	0
<b>Develop</b>	0	0	20	87.0	3	13.0
<b>Implement</b>	6	26.1	9	39.1	8	34.8
<b>Evaluate</b>	2	8.7	5	21.7	16	69.6
<b>Total Percent</b>	-	<b>10.13</b>	-	<b>59.42</b>	-	<b>30.43</b>

We may thus categorize three types of ID practice among the instructors and educators. First, instruction occurs with no knowledge of theory (based on intuition, experience or observation). In the second category, instructors are equipped with the necessary theory but did not put theory into practice (theories at the back of their minds during instruction). The third category puts theory into practice and these are those who understand the learning theory as well as students' needs and practice them very well.

Below are some examples of instruction resulting from ID practice.

**USING ID PROCESS TO DESIGN INSTRUCTION**

Slide Display	
	<p><b>Title :</b> Probability  <b>Target group :</b> Upper Six  <b>Subject</b> Mathematics 5  <b>ID Model Applied :</b> ADDIE  <b>Instructional strategy:</b> Needham Instructional Model</p>
	<p><b>Analysis -</b></p> <p><b>Rationale:</b></p> <ol style="list-style-type: none"> <li>1. Student differentiate the concept and function of probability</li> <li>2. Student able to apply concepts in real situation.</li> </ol> <p><b>Objectives :</b></p> <ol style="list-style-type: none"> <li>1. Calculate the probability of an event</li> <li>2. Understand the meaning of mutually exclusive events</li> <li>3. Use the formula <math>P(A \cup B) = P(A) + P(B) - P(A \cap B)</math></li> </ol>

<div style="border: 1px solid black; padding: 5px;"> <p><b>ORIENTATION</b></p> <p><b>Situation 1</b></p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  K         </div> <div style="text-align: center;">   </div> <div style="text-align: center;">   </div> </div> <div style="margin-top: 10px;">  Q         </div> <div style="margin-top: 10px;">  A         </div> <div style="margin-top: 10px;">  10         </div> <div style="margin-top: 10px;"> <p>A card is drawn randomly from a pack of 52 cards. Find the probability that</p> <ol style="list-style-type: none"> <li>1 it is a king</li> <li>2 it is a black card</li> <li>3 it is a yellow card</li> <li>4 it is even number</li> <li>5 it is an ace</li> </ol> </div> </div> <hr/> <div style="border: 1px solid black; padding: 5px;"> <p><b>ORIENTATION</b></p> <p><b>Situation 2</b></p> <div style="display: flex; align-items: center;"> <div style="border: 1px solid black; padding: 5px; margin-right: 10px;">  </div> <div> <p>If F and G are two events and <math>P(F) = 0.4</math>, <math>P(G) = 0.3</math> and <math>P(F \cap G) = 0.4</math>. find</p> <ol style="list-style-type: none"> <li>1 <math>P(F \cap G)</math></li> <li>2 <math>P(F \cup G)</math></li> <li>3 <math>P(F \cap G)</math></li> </ol> </div> </div> </div>	<p><b>Orientation:</b> Motivate students, attract attention, display of task to enhance further thinking.</p> <p>At the 1<sup>st</sup> phase, the student will be given two situations with two different idea and concept. This is to expose student to problem solving and to be more critical in thinking.</p> <p><b>Situation 1</b> A card is drawn randomly from a pack of 52 cards. Find the probability that</p> <ol style="list-style-type: none"> <li>1. is it a king</li> <li>2. it is a black card</li> <li>3. it is a yellow card</li> <li>4. it is even number</li> <li>5. it is an ace</li> </ol> <p><b>Situation 2</b> If F and G are two events and <math>P(F) = 0.4</math>, <math>P(G) = 0.3</math> and <math>P(F \cap G) = 0.6</math>, find</p> <ol style="list-style-type: none"> <li>1. <math>P(F \cap G)</math></li> <li>2. <math>P(F \cup G)</math></li> <li>3. <math>P(F \cap G)</math></li> </ol>
<div style="border: 1px solid black; padding: 5px;"> <p><b>ELEVATE IDEA</b></p> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>INTRODUCTION</b></p> <p>Theory of Probability provides a basis for assessing the reliability of the conclusion made. Sample data are collected, summarized, analyzed and interpreted and then inference and conclusions are made on the population based probability theory.</p> </div> <div style="width: 45%;"> <p><b>CONCEPT</b></p> <p><math>P(A \cup B) = P(A) + P(B) - P(A \cap B)</math></p> <p>for ANY TWO EVENTS A AND B</p> <p>Probability for three events A, B, and C</p> <math display="block">P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(A \cap C) - P(B \cap C) + P(A \cap B \cap C)</math> <p><math>P(A \cap B) = P(A) \cdot P(B A)</math></p> <p>In general, if A and B are two events with <math>P(A) &gt; 0</math> and <math>P(B) &gt; 0</math>, then the probability of A given B has already occurred is within <math>P(A B)</math> and <math>P(A, B) = P(A) \cdot P(B A)</math></p> </div> </div> </div>	<p><b>Elicit ideas:</b> Bring forward existing ideas from students.</p> <p>In the 2<sup>nd</sup> phase, the teacher conducts the two situations above with the concept of probability. The teacher will:</p> <ol style="list-style-type: none"> <li>1. Teacher conducts question answer session to bring about higher thinking skills in students.</li> <li>2. Explain concept and function.</li> <li>3. A particular concept map is delivered by students.</li> </ol>

5
RESTRUCTURING

**Task 1**

A population of 100 women is divided into three categories: working women (A), degree holders (B) and married women (C), as shown in the Venn diagram.

- 1 she is working
- 2 she is working and with a degree
- 3 she is not married but working and with a degree

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5
RESTRUCTURING

**Task 2**

There are three societies in a school. They are English Language society (E), Malay language Society (M) and Science Society (S). Information regarding a student joining these societies as follows :  $P(E) = 0.4$ ,  $P(E \cup M) = 0.65$ ,  $P(E \cup S) = 0.8$ ,  $P(E \cap M) = 0.15$ ,  $P(E \cap S) = 0.2$ ,  $P(M \cap S) = 0.2$  and  $P(E \cap M \cap S) = 0.95$

A student is selected at random from the school. Find the probability that the student is

- 1 a member of Malay language Society
- 2 a member of all the three societies
- 3 not a member of any society

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5
RESTRUCTURING

**Task 3**

A company has 100 salesperson, 40% of them are males and the rest are females. Sixteen of the male salespersons are bachelors. From all the female salespersons, 36 of them are married. A salesperson is selected at random from the company. If it is known that the salesperson selected is single, what is the probability that the salesperson is male ?

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5
RESTRUCTURING

**Task 4**

Analysis of 80 applications for a vacancy shows that 6% of the applicants are males, and from all the male applicants, 1/3 are degree holder. From all the female applicants, half are degree holders. Assume that each applicant has an equal chance of getting the job.

find the probability that the successful applicant is a male with a degree. If it is known that the successful applicant is a degree holder what is the probability that the applicant is a female.

**Restructuring ideas/Generating:** *Develop new ideas or modify existing ideas.*

1. Teacher shows Task1 and generates ideas from students.
2. Students observe and restructure their former idea or knowledge.

**Restructuring ideas:** *Develop new ideas or modify existing ideas.*

1. A display of some of the basic questions that can be asked to elicit ideas.
2. Students communicate to generate new idea.

To determine students' understanding about concept and application. A few question have been constructed:

**Task 1**

A population of 100 women is divided into three categories: working women (A), degree holders (B) and married women (C), as shown in the Venn diagram. What is the probability

- (a) she is working
- (b) she is working and with a degree
- (c) she is not married but working and with a degree

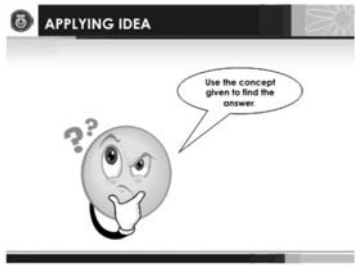
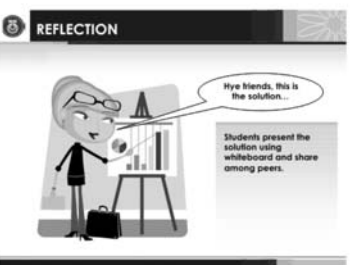
**Task 2**

There are three societies in a school. They are English Language society (E), Malay language Society (M) and Science Society (S). Information regarding a student joining these societies as follows :

$P(E) = 0.4$ ,  $P(E \cup M) = 0.65$ ,  $P(E \cup S) = 0.8$ ,  $P(E \cap M) = 0.15$ ,  $P(E \cap S) = 0.2$ ,  $P(M \cap S) = 0.2$  and  $P(E \cap M \cap S) = 0.95$

A student is selected at random from the school. Find the probability that the student is

- A) a member of Malay language Society
- B) a member of all the three societies
- C) not a member of any society

	<p><b>Task 3</b> A company has 100 sales people, 40% of them are males and the rest are females. Sixteen of the male salespersons are bachelors.</p> <p>From all the female salespersons, 36 of them are married. A salesperson is selected at random from the company. If it is known that the salesperson selected is single, what is the probability that the salesperson is male?</p> <p><b>Task 4</b> Analysis of 80 applications for a vacancy shows that <math>\frac{3}{4}</math> of the applicants are males, and from all the male applicants, <math>\frac{1}{3}</math> is degree holder. From all the female applicants, half are degree holders. Assume that each applicant has an equal chance of getting the job.</p> <ol style="list-style-type: none"> <li>Find the probability that the successful applicant is a male with a degree.</li> <li>If it is known that the successful applicant is a degree holder, what is the probability that the applicant is a female?</li> </ol>
 <p>The slide is titled 'APPLYING IDEA' and features a cartoon character with a thoughtful expression and question marks above its head. A speech bubble says, 'Use the concept given to find the answer.'</p>	<p><b>Applying idea:</b> The idea developed prior to this is applied in a new situation.</p> <ol style="list-style-type: none"> <li>They are given time to complete the task.</li> <li>After completing the task the student present their solutions using whiteboard and share how they obtained the answer.</li> <li>Students discusses solutions with peers and tries to apply concept in different situations</li> </ol>
 <p>The slide is titled 'REFLECTION' and shows a cartoon character pointing to a whiteboard with a bar chart. A speech bubble says, 'Hye blends, this is the solution...'. A text box on the whiteboard reads, 'Students present the solution using whiteboard and share among peers.'</p>	<p><b>Reflection:</b> Evaluate how far the lesson has modified past idea or idea before lesson started.</p> <ol style="list-style-type: none"> <li>The students have to present the answer among peers.</li> <li>Student should explain how their get the answer.</li> <li>Students are required to answer all Q&amp;A from their peers.</li> </ol>

8
▶
**SOLUTION**

**Task 1**

Let A : the woman is working  
 B : the woman has a degree  
 C : the woman is married

(a)  $n(S) = 100$   
 $n(A) = 25 + 10 + 5 + 50$   
 $n(B) = n(A)$   
 $n(C) = 50$   
 $n(S) = 100$   
 $= 0.8$

Probability the woman selected is working is 0.8  
 $n(A \cap B) = 10 + 5 + 5 = 20$   
 $P(A \cap B) = \frac{n(A \cap B)}{n(S)}$   
 $= \frac{20}{100}$   
 $= 0.2$

Probability total the women is a degree holder and working is 0.15  
 $n(C \cap A \cap B) = 10 + 5$   
 $P(C \cap A \cap B) = \frac{n(C \cap A \cap B)}{n(S)}$   
 $= \frac{15}{100} = 0.15$

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8
▶
**SOLUTION**

**Task 2**

a)  $P(D \cup M) = P(D) + P(M) - P(D \cap M)$   
 $0.85 = 0.4 + P(M) - 0.15$   
 $P(M) = 0.45 - 0.4 + 0.15$   
 $= 0.2$   
 $P(D \cap S) = P(D) - P(D \cap S)$   
 $= 0.4 - P(D \cap S)$   
 $P(S) = P(D \cap S) + P(D) + P(M) + P(S) - P(D \cap M) - P(D \cap S) - P(M \cap S) + P(D \cap M \cap S) = 0.1$   
 $P(D \cap M \cap S) = 0.1$   
 P : not a member of any society  
 $= 1 - P(D \cup M \cup S)$   
 $= 1 - 0.95$   
 $= 0.05$

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8
▶
**SOLUTION**

**Task 3**

	Male	Female	Total
Single	16	24	40
Married	24	36	60
Total	40	60	100

All the information is given in the table above  
 $P(\text{female} / \text{single}) = \frac{P(\text{female} \cap \text{single})}{P(\text{single})}$   
 $= \frac{24}{40}$   
 $= \frac{3}{5}$

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8
▶
**SOLUTION**

**Task 4**

Let S : sample space consisting of all the applicants  
 W : applicant is a male  
 F : applicant is a female  
 H : applicant is a degree holder

$n(S) = 80$ ,  $n(W) = 50$ ,  $n(F) = 30$ ,  $n(H) = 20$   
 $n(W \cap H) = 15$ ,  $n(W \cap \bar{H}) = 35$ ,  $n(F \cap H) = 5$ ,  $n(F \cap \bar{H}) = 25$   
 $n(S) = 80$   
 $= 0.25$

The probability that the successful applicant is a male degree holder is 0.25  
 b)  $P(W \cap H) = P(W \cap H)$   
 $= \frac{15}{80}$   
 $= \frac{3}{16}$   
 (Decrease  $P(W \cap H) = n(W \cap H) / n(S)$  and  
 $n(S) = 80$ )  
 $P(H) = \frac{n(H)}{n(S)} = \frac{20}{80} = 0.25$

c) If it is known that the successful applicant is a degree holder, then the probability that the applicant is a female is 1/3

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## ID FOR A PHYSICS EXPERIMENT LESSON PLAN

**Subject** : Physics

**Form** : 4A

**Time** : 9.30am – 10.20am

**Duration** : 50 minutes

**Venue** : Physics Lab

**Chapter** : 5. Light

**Topic** : Understanding Lenses

Activity 5.4: Lens


(a) Focal Point and Focal Length

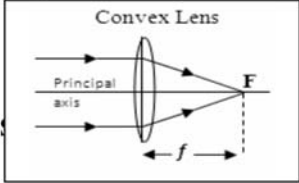
**Objectives** : At the end of the lesson, students should be able to:

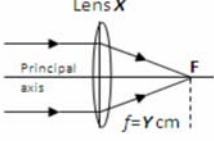
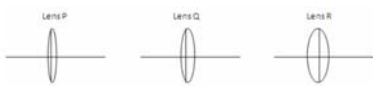
(a) explain focal point and focal length

(b) determine the focal point and focal length of a convex lens

**Prior Knowledge:** Students have learnt about focal point and focal length for convex lens theoretically during the previous class.

Phases	Teacher/ Student Activities	Teaching Aids/ Materials
<p><b>1. Orientation</b></p> <ul style="list-style-type: none"> <li>· Pictures:                             <ul style="list-style-type: none"> <li>(a) Telescope</li> <li>(b) Spectacles</li> <li>(c) Microscope</li> <li>(d) Magnifying glass</li> <li>(e) Camera</li> </ul> </li> <li>· Concave lens only used in spectacles for correction of short-sightedness</li> </ul>	<p>(i) Teacher shows the pictures on the slides. Teacher asks several questions about the slides:</p> <ul style="list-style-type: none"> <li>- Name the optical devices shown on the slides.</li> <li>- What type of material used in these optical devices? <b>(Answer: Lens)</b></li> <li>- What type of lens is used? <b>(Answer: Convex lens)</b></li> </ul> <p>(ii) Teacher tells students today they will carry out an experiment about convex lens.</p>	<ul style="list-style-type: none"> <li>· <b>Slide 1:</b> Pictures of optical devices</li> <li>· <b>Slide 2:</b> Title of the experiment</li> </ul> <div data-bbox="822 995 1157 1245" style="border: 1px solid black; padding: 5px;">  </div> <div data-bbox="878 1300 1161 1506" style="border: 1px solid black; padding: 10px; text-align: center;"> <p><b>Activity 5.4: Lens (Focal Point and Focal Length)</b></p> </div>

<p><b>1. Generating/Elicitation the Ideas</b></p> <ul style="list-style-type: none"> <li>□ <b>Focal point, F</b> is a common point on the principal axis where all rays parallel to the axis converge to it after passing through a convex lens.</li> <li>□ <b>Focal length, f</b> is the distance between the focal point and the optical centre.</li> <li>□</li> </ul>	<ul style="list-style-type: none"> <li>(i) Teacher request three students to state the characteristics of convex lens.</li> <li>(ii) Teacher shows a ray diagram of convex lens on a mahjong paper. Teacher request two students to determine the focal point and focal length.</li> <li>(iii) Then, teacher asks another two students to state the definition of focal point and focal length.</li> </ul>	<ul style="list-style-type: none"> <li>□ <b>Mahjong paper:</b> Ray diagram for a convex lens</li> </ul>  <p style="text-align: center;">Convex Lens</p> <p style="text-align: center;">Principal axis</p> <p style="text-align: center;">F</p> <p style="text-align: center;">← f →</p> <ul style="list-style-type: none"> <li>□</li> </ul>
<p><b>2. Structuring the Idea</b></p> <ul style="list-style-type: none"> <li>□ Procedures to carry out an experiment:</li> <li>(a) Aim</li> <li>(b) Apparatus/ Material</li> <li>(c) Apparatus setup</li> <li>(d) Procedures</li> <li>(e) Safety precaution</li> </ul>	<ul style="list-style-type: none"> <li>(i) Teacher shows the problem of the experiment on the slide. Based on the problem, teacher request one student to state the aim of the experiment.</li> <li>(ii) Teacher shows the apparatus needed. She request students randomly to name the apparatus.</li> <li>(iii) Teacher asks students to read the procedures while teacher shows the steps.</li> <li>(iv) Teacher lets the students to conduct the experiment.</li> <li>(v) Teacher reminds the students to give cooperation to their classmates and be aware of the danger of electricity when dealing with electrical connection. They are given 15 minutes to conduct the experiment.</li> </ul>	<ul style="list-style-type: none"> <li>□ S</li> </ul> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;"><b>Aim</b></p> <p style="text-align: center;">How are the focal point and focal length of a convex lens determine ?</p> </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;"><b>Apparatus &amp; Materials</b></p> <ul style="list-style-type: none"> <li>→ Lens holder</li> <li>→ White screen</li> <li>→ Metre rule</li> <li>→ A4 paper</li> <li>→ 3 convex lenses with different thickness</li> <li>→ Ray box</li> <li>→ Power supply</li> </ul> </div> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;"><b>Procedure</b></p> <ol style="list-style-type: none"> <li>1. The apparatus was arranged as shown in the diagram.</li> <li>2. The screen and lens P were aligned and adjusted so that a sharp image of the distant object (window/ light from the ray box) would fall on the screen.</li> <li>3. The distance between lens P and the screen was measured and recorded.</li> <li>4. The focal point for lens P was marked and its focal length was labeled on a piece of paper.</li> <li>5. Procedures 2, 3 and 4 were repeated for lenses Q and R.</li> </ol> </div>

<p><b>1. Application of the Ideas</b></p> <p>□ <i>Results:</i></p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="font-size: small;">Lens</th> <th style="font-size: small;">P</th> <th style="font-size: small;">Q</th> <th style="font-size: small;">R</th> </tr> </thead> <tbody> <tr> <td style="font-size: x-small;">Focal length, <math>f</math> (cm)</td> <td>20.0</td> <td>15.0</td> <td>10.0</td> </tr> <tr> <td style="font-size: x-small;">Focal length, <math>f</math> (m)</td> <td>0.20</td> <td>0.15</td> <td>0.10</td> </tr> <tr> <td style="font-size: x-small;">Power = <math>1/f</math> (in m) (D)</td> <td>5.0</td> <td>6.7</td> <td>10.0</td> </tr> </tbody> </table> <p style="margin-top: 10px;">□ <i>Observation:</i></p> <div style="text-align: center;">  </div>	Lens	P	Q	R	Focal length, $f$ (cm)	20.0	15.0	10.0	Focal length, $f$ (m)	0.20	0.15	0.10	Power = $1/f$ (in m) (D)	5.0	6.7	10.0	<p>(i) After students have finished conducting the experiment, teacher asks them to keep all the apparatus and sit at their own group. Then, teacher calls each group to write down their results on the mahjong paper.</p> <p>(ii) Then, teacher asks three students randomly to draw the ray diagram for convex lens based on their observation.</p> <p>(iii) Teacher discusses the results and observation of the experiment and relates it to the theory.</p> <p>(iv) Teacher asks students to conclude the experiment.  <b>(Conclusion:</b> The thicker is the convex lens, the shorter is its focal length.)</p>	<p>□ <b>Mahjong paper:</b> Results and Observation</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="font-size: small;">Group</th> <th style="font-size: small;">1</th> <th style="font-size: small;">2</th> <th style="font-size: small;">3</th> <th style="font-size: small;">4</th> <th style="font-size: small;">5</th> <th style="font-size: small;">6</th> </tr> <tr> <th style="font-size: x-small;">Lens P</th> <th style="font-size: x-small;">P</th> <th style="font-size: x-small;">Q</th> <th style="font-size: x-small;">R</th> <th style="font-size: x-small;">P</th> <th style="font-size: x-small;">Q</th> <th style="font-size: x-small;">R</th> </tr> </thead> <tbody> <tr> <td style="font-size: x-small;">Focal length, <math>f</math> (cm)</td> <td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td style="font-size: x-small;">Focal length, <math>f</math> (m)</td> <td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <td style="font-size: x-small;">Power = <math>1/f</math> (in m) (D)</td> <td></td><td></td><td></td><td></td><td></td><td></td> </tr> </tbody> </table> <div style="text-align: center; margin-top: 10px;">  </div>	Group	1	2	3	4	5	6	Lens P	P	Q	R	P	Q	R	Focal length, $f$ (cm)							Focal length, $f$ (m)							Power = $1/f$ (in m) (D)						
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<p><b>2. Reflection</b></p> <p><b>Conclusion:</b>                  The thicker is the convex lens, the shorter is its focal length.</p> <p><b>Power of lens =</b></p> <p style="text-align: center;">_____</p> <p style="text-align: center;">( )</p>	<p>(i) Teacher asks students what will happen to focal length if we increase the thickness of a convex lens.</p> <p>(ii) Then, teacher asks students what can we obtain when we measure the value of _____ in m.</p>																																																				

## RECOMMENDATIONS

Results from the research showed that the instructional materials employing ID theories, models and learning theories are more effective in acquiring correct understanding of concepts. These results also showed that the emphasis on the ID theories, models and learning theories in designing instructional materials is important as it gives more meaningful learning to the students. Hence, educators and instructors have to take into consideration ID principles when they are designing material for the purpose of instruction.

## ACKNOWLEDGEMENTS

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