### The van Hiele Model and its Implication in Blind Students' Understanding in Geometry

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#### **INFLUENCES UPON VAN HIELE'S THEORY**



**Evolution of Insight Knowledge From Lower To Higher Levels** 

- Structural expansion
- Structural refinement
- The construction of superstructures
- The transition to isomorphic structures

### THE TERM "INSIGHT"

- Xan Hiele (1986) investigates the functions of insight during a process of learning and emphasises its importance:
  - It is highly important to know how the child itself experiences insight. The acquisition of insight into the many spheres of matter that lie within the range of the dealings and aptitudes of a human being is one of the basic necessities of life (p.241).

### LEVELS OF MENTAL DEVELOPMENT IN GEOMETRY

#### The Van Hiele Model identifies five levels of thinking

### Level O (Recognition):

Recognition of shapes as a whole

### Levels 1 & 2 (Analysis & Ordering):

Progressing to discovery of the properties of figures and informal reasoning about these figures and their properties

### Levels 3 & 4 (Deduction & Rigour):

Culminating in a rigorous study of axiomatic geometry (Fuys, et al., 1988)



#### •Passive Touch vs Active Touch? (touch and being touched)

# Tactile stimulus Tactile/haptic Perception

**Model of Haptic Perception** 



# STUDIES INVESTIGATING THE ROLE OF ACTIVE TOUCH

- The sense of touch depends on the skills of the individual by using efficiently his/her hands (Ballesteros & Heller, 2008)
- Accuracy and speed are important variables in recognition of objects by touch (Withagen et al., 2011)
- Comprehension of the spatial structure relies on the integration of visual, audio and tactile experiences (Warren, 1994)
- Three-dimensional objects are explored faster than the twodimensional ones (Homa et al., 2009)
- Individuals with adventitiously blindness had greater precision in shape recognition than individuals with congenital blindness (Toroj et al., 2011)





investigate the appropriateness of the van Hiele model in classifying blind students' understanding in geometry.

### Levels of Understanding

Thinking of teaching methods based on the van Hiele model **Congenitally blind** 

Adventitiously blind

Sex	agea	LP	Cause	Sex	agea	LP	cause
F	16	No	PHPV	Μ	19	No	Glaucoma
Μ	17	No	Optic nerve atrophy	Μ	16	No	Glaucoma
F	16	No	Optic nerve atrophy	F	17	Yes	Iridocyclitis
Μ	17	Yes	Congenital cataract	F	17	Yes	Glaucoma
F	16	No	RP	F	16	No	-
М	16	Yes	RP	F	18	Yes	-
М	18	Yes	RLF	F	17	No	-
М	18	No	RLF	Μ	17	No	-

Note: F= female; M= male; LP= light perception; PHPV= persistent hyperplastic primary vitreous; RP = retinitis pigmentosa; RLF=retrolental fibroplasias. <sup>a</sup> Age given in years.



# INSTRUMENT - STIMULUS MATERIAL









# 2<sup>nd</sup> Group









### 3<sup>rd</sup> Group







### **QUALITATIVE CLASSIFICATION OF STUDENTS' RESPONSES**

## Key: [coding system of Fuys et al. (1988)]

- Unable to respond
- × 0\* Weak response
- g Responded with guidance
- p Responded after prompting
- s Responded spontaneously

# THINK ALOUD PROTOCOLS-SCORING

#### Method: Holistic approach

The scoring was based on the participant's overall response

#### 1=min. value & 3=max. value

- 3 = participant provides correct definitions of the shape and it's properties
- 2 = participant provides correct definitions of the shape without defining it's correct properties (or vice versa).
- 1 = participant provides incorrect definitions of the shape accompanied with incorrect properties

#### Example for a trapezium

Participant: Well this shape is kind of parallelogram but these two opposite sides are not parallel

Total Score = 2



Table 2 provides an approximate classification into van Hiele's levels of understanding regarding two- and three-dimensional shapes in terms of

- x a. their recognition (basic concepts),
- × b. their properties, and
- × c. their patterns.

# RESULTS\_1 (BASIC CONCEPTS)

- According to the collected data, students' level of understanding lies mostly within a transitional phase between levels 0 and 1 (33.13%)
- 5 students' thinking or/understanding was categorised between level 1 and 2.
- Most of the participants seemed to be level 0 thinkers (van Hiele's level of understanding)

# RESULTS\_2 (BASIC CONCEPTS)

- Participants were familiar with basic geometrical shapes (circles, triangles, rectangles or squares) but became confused and sometimes frustrated with polygons
- Failure to analyse the shapes in terms of their parts and properties (e.g. hexagon with no sides or trapezium with six or seven corners
- All participants tried to analyse and work out the three-dimensional shapes as twodimensional
- They did not have a system of counting with stable reference points

# RESULTS\_3 (PROPERTIES)

- The thinking of the participants was almost uniformly at Level 0 with an inclination to Level 1 (56.25%)
- Most times their recognition was on an "I felt it" basis rather than on the basis of the properties of the shapes in question
- Only 3 participants seemed to be very confident about the way they counted angles or sides

# RESULTS\_4 (PATTERNS)

× 8 of the participants did not seem to be aware that every two-dimensional shape has the same number of sides and angles

 A participants did not face any problem with patterns; instead, after they became familiar with the procedure they started to give spontaneously all the information about a shape

 Big confusion took place with all threedimensional shapes apart from spheres

# RESULTS\_4 (SCORING THINK-ALOUD PROTOCOLS)

### <u>Average Scoring of Think-aloud Protocols RELATED</u> <u>TO Van Hiele Levels of Understanding</u>

× 1.43< Average Score < 2.09 (Level 0 to Level 1)

× 1.79< Average Score < 2.57 (Level 1 to Level 2)

### STRATEGIES USED IN IDENTIFYING SHAPES

- Holding the shape in front of them (near their face or near their chest);
- marking an angle with a thumb and exploring the shape with the other hand while rotating it. This is actually an exploration of a two-dimensional shape in a three-dimensional way, and
- Putting the shape firmly on the desk. This represents an exploration of a two-dimensional shape in a two-dimensional way. (The desk may be considered as the Cartesian coordinate system and the shape could be recognised only from its two-dimensional properties.

# DISCUSSION\_1

- x 1<sup>st</sup> research objective: "applicability of van Hiele theory"
  - 1. Reasonable framework for describing the geometrical understanding of students with blindness and sheds light on students' insights.

### IT HAS TO BE ENRICHED BY TACTILE STRATEGIES

2. A single level is not adequate to describe and classify students' thinking → a synthesis of levels might provide a more integrated "picture" of students' understanding in geometry



- Previous visual experience (for adventitiously blind participants) seemed to play an important role in haptic perception (Postma et al., 2008).
- Enclosure and Lateral Motion seem to relate positively to van Hiele's 1 & 2 Levels of Understanding

Level 1 & 2 = Progressing to discovery of the properties of figures and informal reasoning about these figures and their properties

# DISCUSSION\_3

### 2<sup>nd</sup> research objective: to consider implications of teaching methods

The structural analysis provides information about: a. students' levels of thinking , and b. factors which affected students' performances at different stages of the task (e.g., vocabulary, tactile perception, misconceptions, learning styles)



# DISCUSSION\_4

- improvement of classroom practice when students' understanding has been classified into levels, and
- teacher's training in order to facilitate as much as possible students' understanding using all the parameters of tactual shape perception (Millar, 1997)

# 

Pegg (1985) praises the dynamic character of van Hiele's model, stressing that:

**×** The van Hiele theory is most useful for teachers in the advice it gives to planning for instruction. The fact that a pupil's thinking can be classified at a particular level is not important itself. What is important are the implications to the teacher of the type of content and methods that are appropriate and the need to respond to pupils at their level of thinking. (p. 8)

# ALSO...

- the number of levels seem to be flexible,
- \* performances generally seem to be spread across levels, and
- x performances are determined by what is taught.



This implies that the nature of the van Hiele's levels are more psychological than logical and undoubtedly has a bearing on teaching processes (Clements & Battista, 1992)

# THE RESULTS BRING US TO ....

**× ZDP** (Zone of Proximal Development)/Vygotsky)

Students' Readiness (at THEIR level of Understanding)

 Issues of differentiation (content, process, product and learning environment)

**x Rtl** (Response to Intervention)

# LIMITATIONS - FUTURE RESEARCH

- The sample was small. It is need to conduct further studies with more participants -> correlations between types of active touch and levels of understanding.
- It is suggested the use of two cameras mounted on tripods (the one right over the student's shoulder and student's fingers.
- The analysis of the video recordings is proposed to be made by a special image processing software (such as AVID).
- Discrete scorings of the think-aloud protocols for each shape and attribute them to the corresponding Level of Understanding (Cluster Scoring System)

