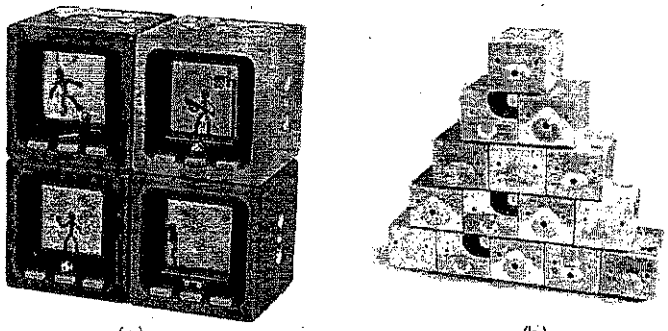
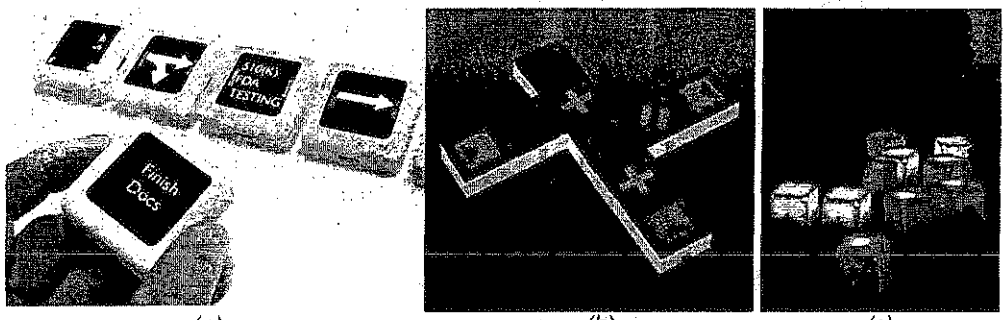


(a) (b)

Fig. 1



(a) (b) (c)

Fig. 2

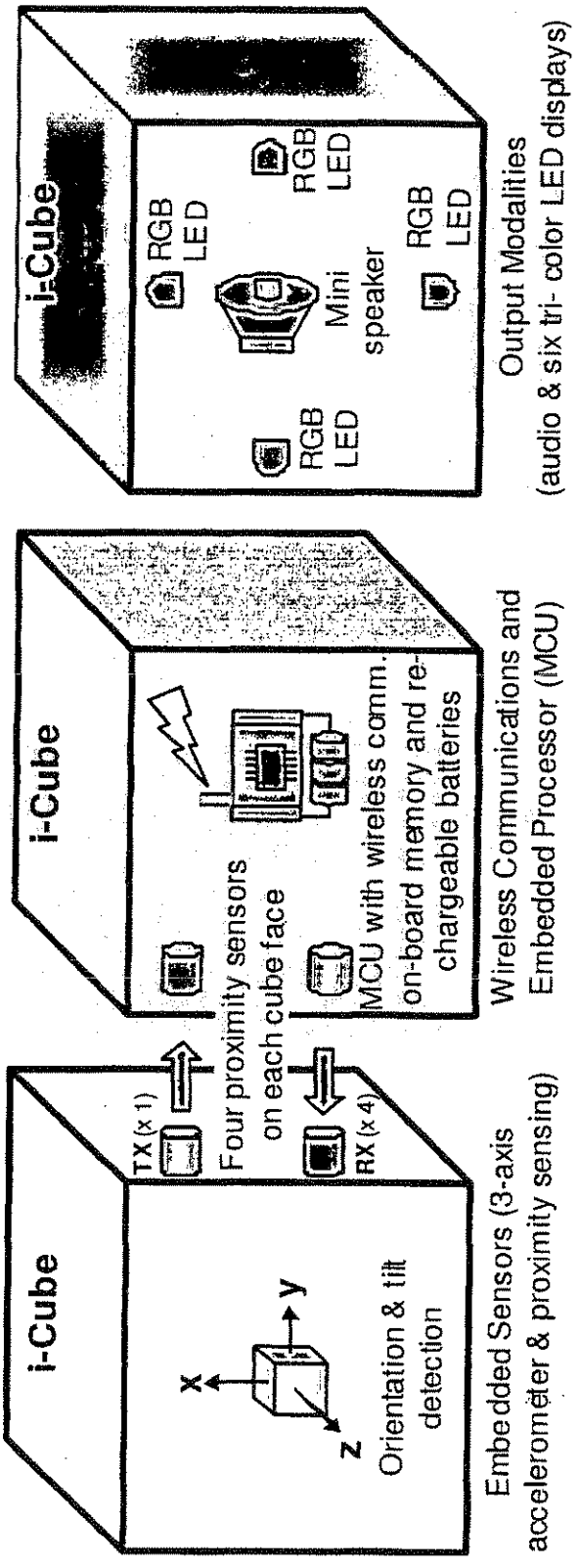
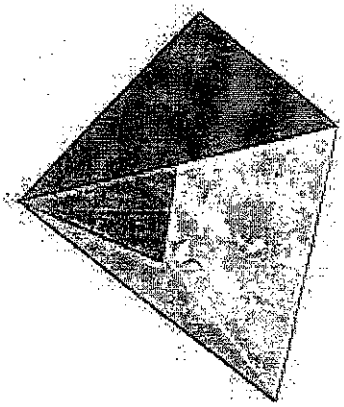
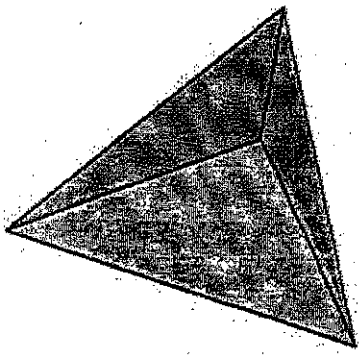

i-Cube
RGB LED
RGB LED
Mini speaker
RGB LED
RGB LED
Output Modalities (audio & six tri- color LED displays)
i-Cube
MCU with wireless comm. on-board memory and re-chargeable batteries
Four proximity sensors on each cube face
Wireless Communications and Embedded Processor (MCU)
i-Cube
TX (x 1)
RX (x 4)
x
y
z
Orientation & tilt detection
Embedded Sensors (3-axis accelerometer & proximity sensing)
300

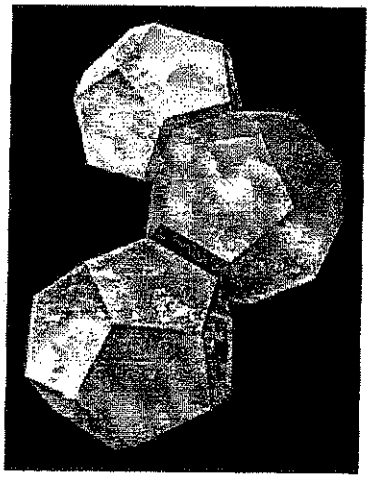
Fig. 3



(c)



(b)



(a)

Fig. 4

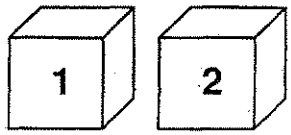
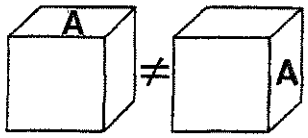
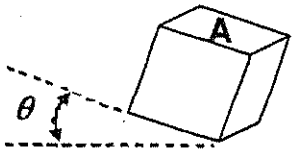
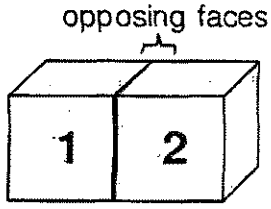
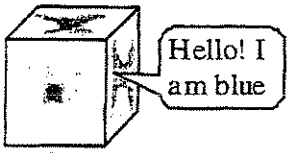
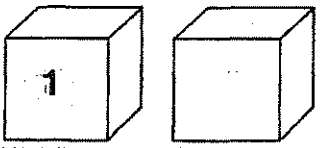
i-Cube Feature	Signal Type	Description and Possible Uses	Pictorial Description
Block identity	Input	The i-Cube has a unique digital block identity known to the interactive application.	
Block vertical orientation	Input	The vertical orientation of the i-Cube can be determined so that the top cube face of the i-Cube can be known to the interactive application.	
Block tilt angle	Input	The tilt angle of the i-Cube with respect to the direction of Earth's gravity can be determined and known to the interactive application.	
Adjacent blocks and their relative orientation	Input	The opposing faces of adjacent i-Cubes, the relative orientation of these opposing faces, and the identities of these adjacent i-Cubes can be determined by the interactive application.	
Audio output	Output	The i-Cube is able to provide audio output e.g. audio playback using for example, a speaker. (Possible use: the interactive application may verbally 'count' the number of i-Cubes in a stack or teach numbers with a visual sense of spatial proportion).	 Audio feedback and communication with user
Visual output	Output	The i-Cube is able to provide visual output e.g. each i-Cube and/or i-Cube face can be illuminated with a different color and/or intensity. (Possible use: colors can be used to highlight which i-Cube(s) should be picked up or which i-Cube face(s) are currently active).	 Highlight a block face Change color of the block

Fig. 5

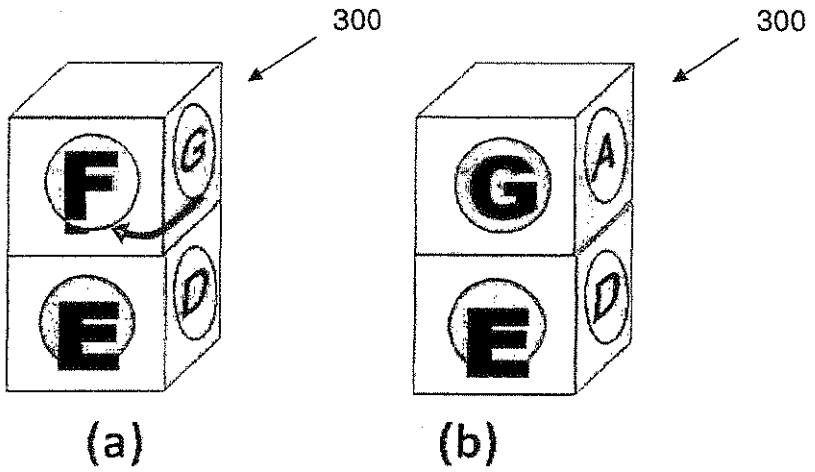

300
300
F
G
E
D
G
A
E
D
(a)
(b)

Fig. 6

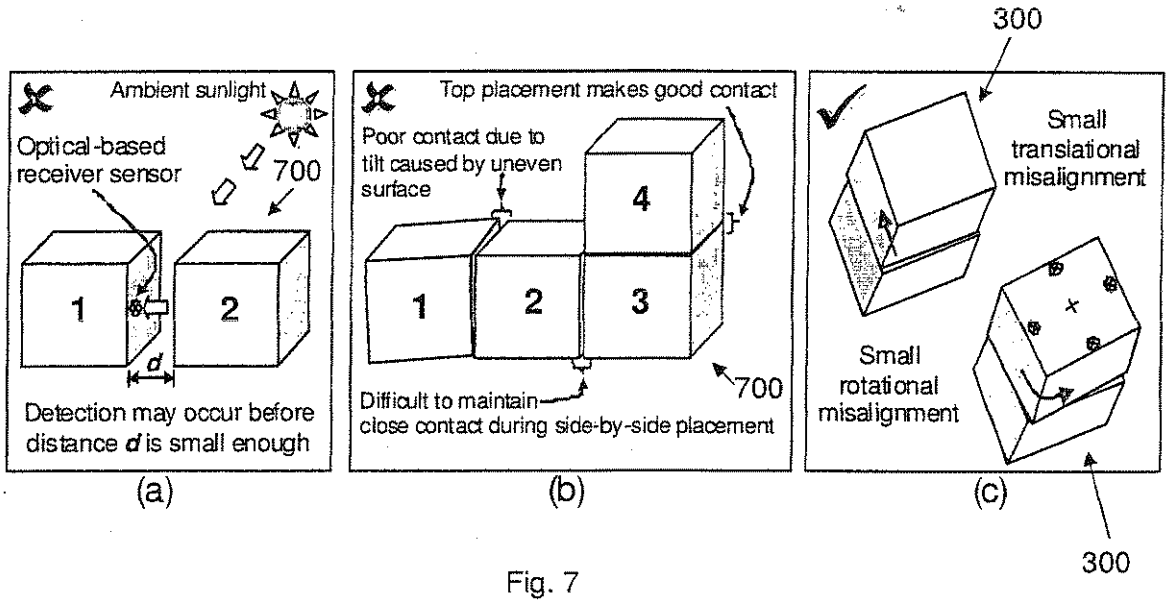

Ambient sunlight
Optical-based receiver sensor
700
1
2
d
Detection may occur before distance d is small enough
(a)
Top placement makes good contact
Poor contact due to tilt caused by uneven surface
4
1
2
3
700
Difficult to maintain close contact during side-by-side placement
(b)
300
Small translational misalignment
Small rotational misalignment
(c)
300

Fig. 7

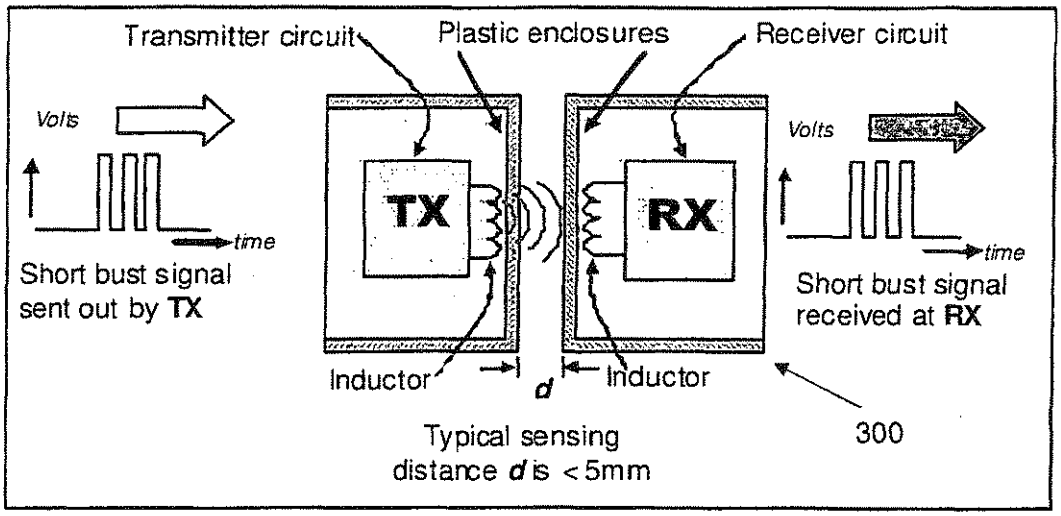

Transmitter circuit
Plastic enclosures
Receiver circuit
Volts
time
Short bust signal
sent out by TX
TX
RX
Volts
time
Short bust signal
received at RX
Inductor
d
Inductor
Typical sensing
distance d is < 5mm
300

Fig. 8

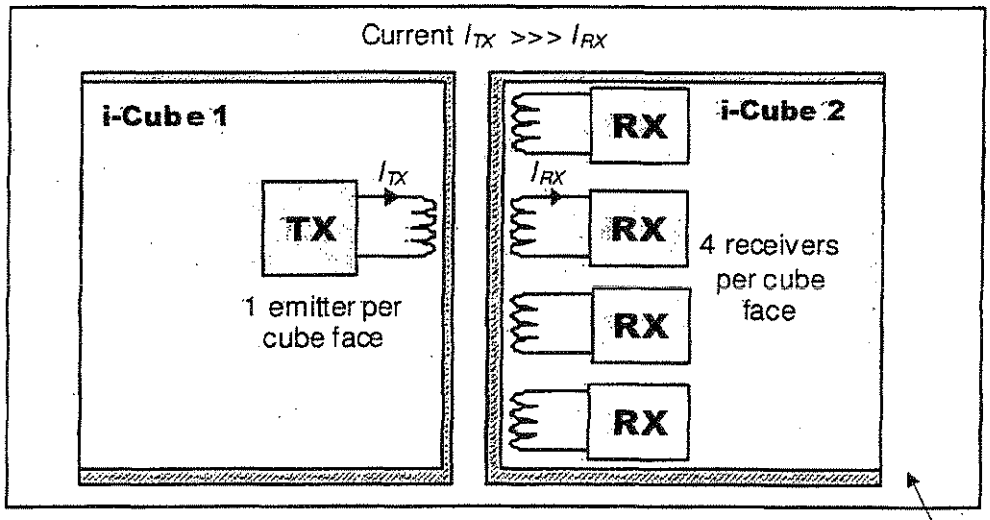

Current I_{TX} >>> I_{RX}
i-Cube 1
I_{TX}
TX
1 emitter per
cube face
i-Cube 2
RX
I_{RX}
RX
4 receivers
per cube
face
RX
RX
300

Fig. 9

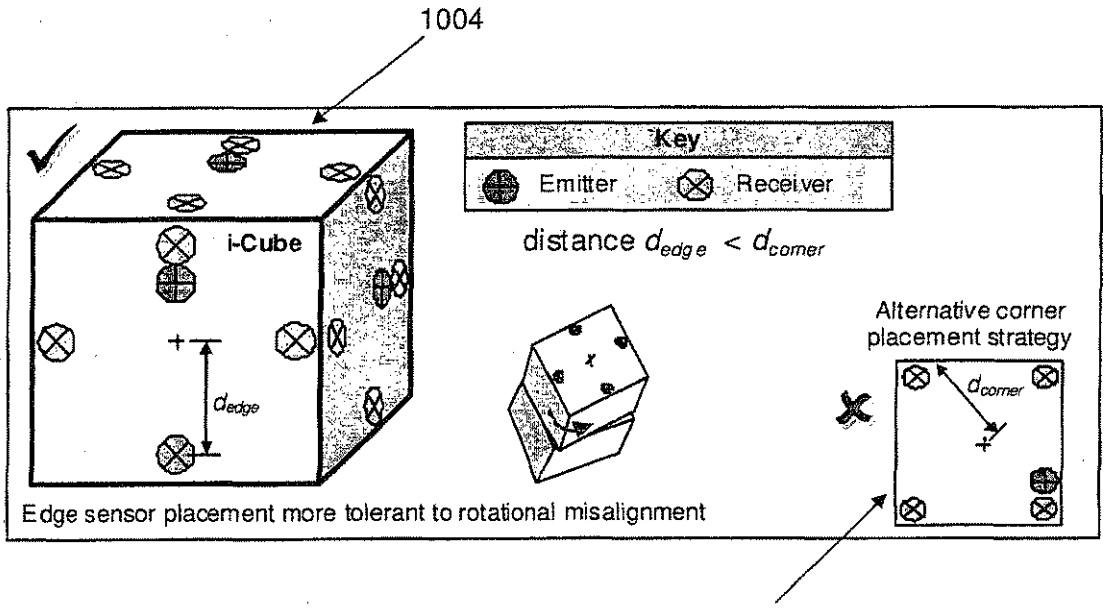

1004
Key
Emitter
Receiver
i-Cube
distance d_{edge} < d_{corner}
Alternative corner placement strategy
d_{edge}
d_{corner}
Edge sensor placement more tolerant to rotational misalignment
1002

Fig. 10

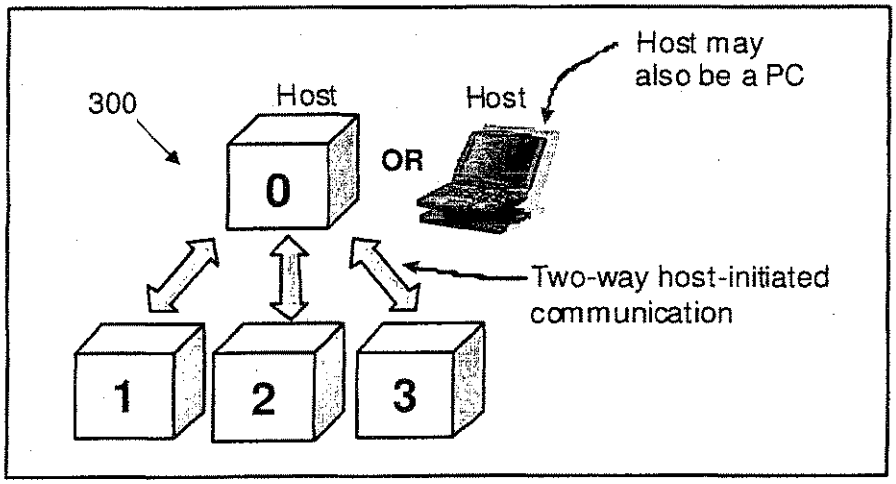

300
Host
Host
Host may also be a PC
OR
0
Two-way host-initiated communication
1
2
3

Fig. 11

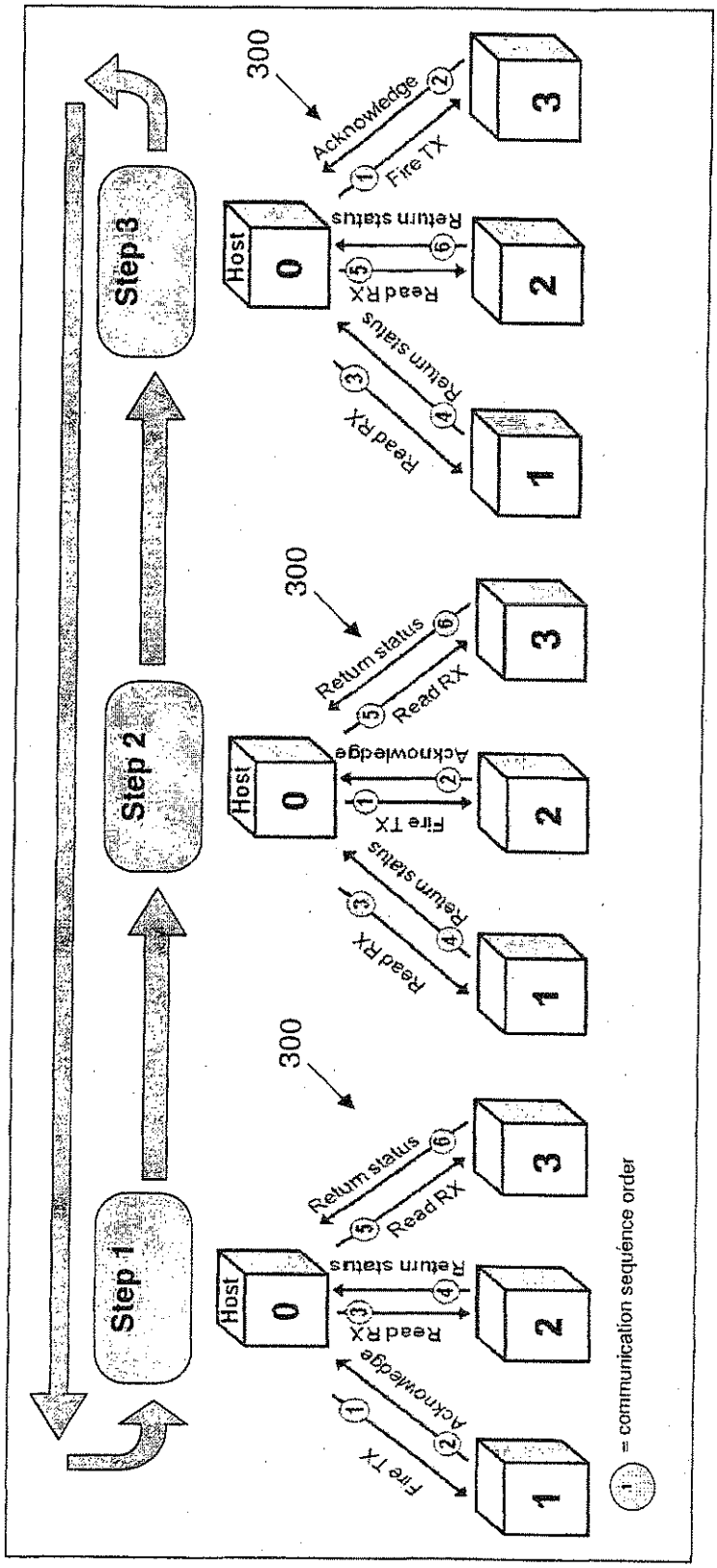

Step 1
Step 2
Step 3
300
Host
0
1
2
3
Fire TX
Acknowledge
Read RX
Return status
= communication sequence order

Fig. 12

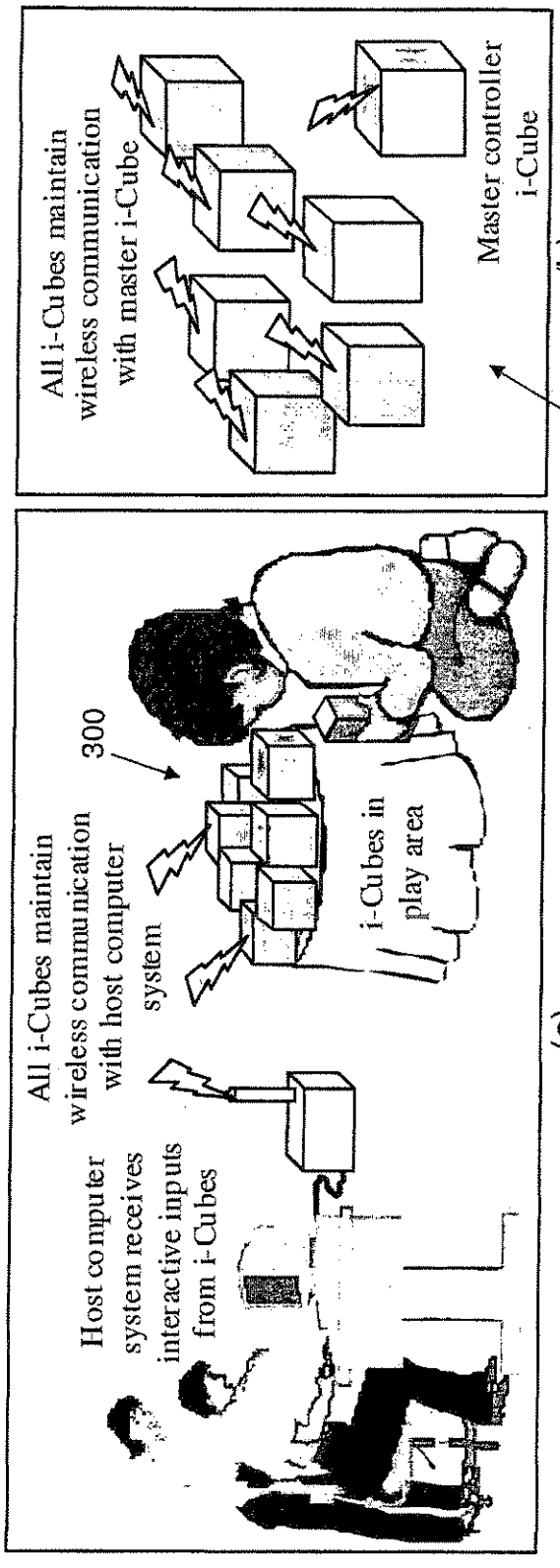

All i-Cubes maintain wireless communication with master i-Cube
Master controller i-Cube
(b)
300
All i-Cubes maintain wireless communication with host computer system
300
i-Cubes in play area
Host computer system receives interactive inputs from i-Cubes
(a)

Fig. 13

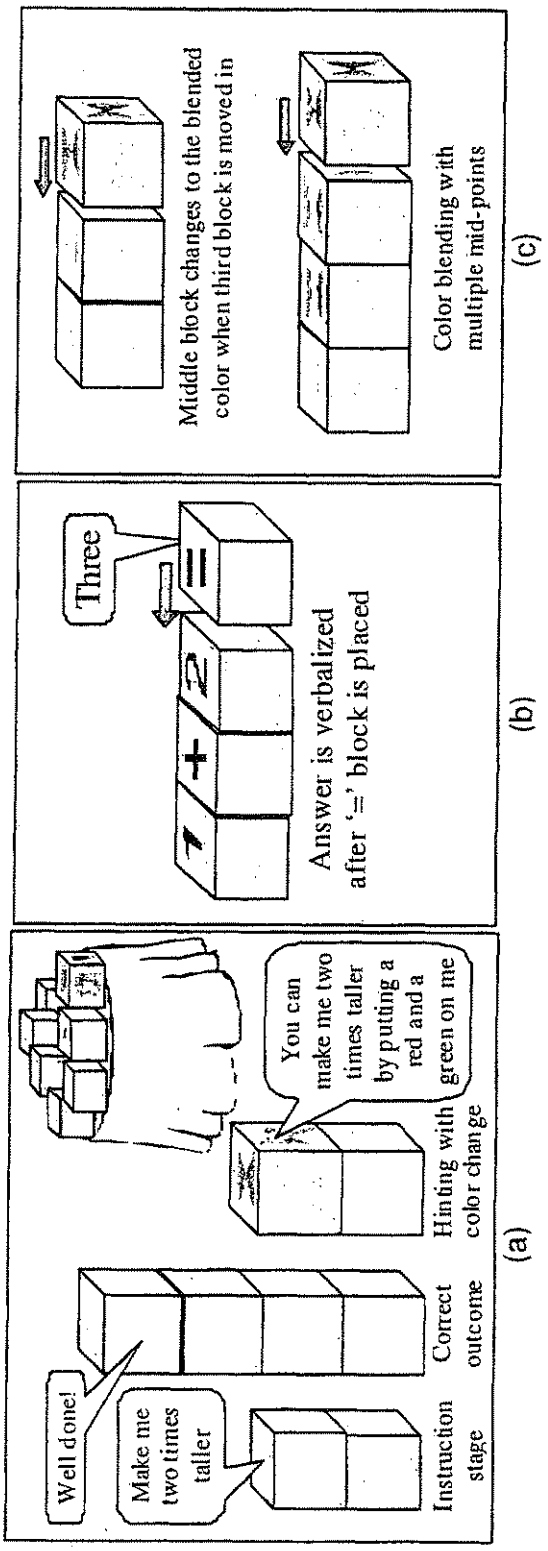

Instruction stage
Make me two times taller
Well done!
Correct outcome
Hinting with color change
You can make me two times taller by puting a red and a green on me
(a)
Answer is verbalized after '=' block is placed
Three
(b)
Middle block changes to the blended color when third block is moved in
Color blending with multiple mid-points
(c)

Fig. 14

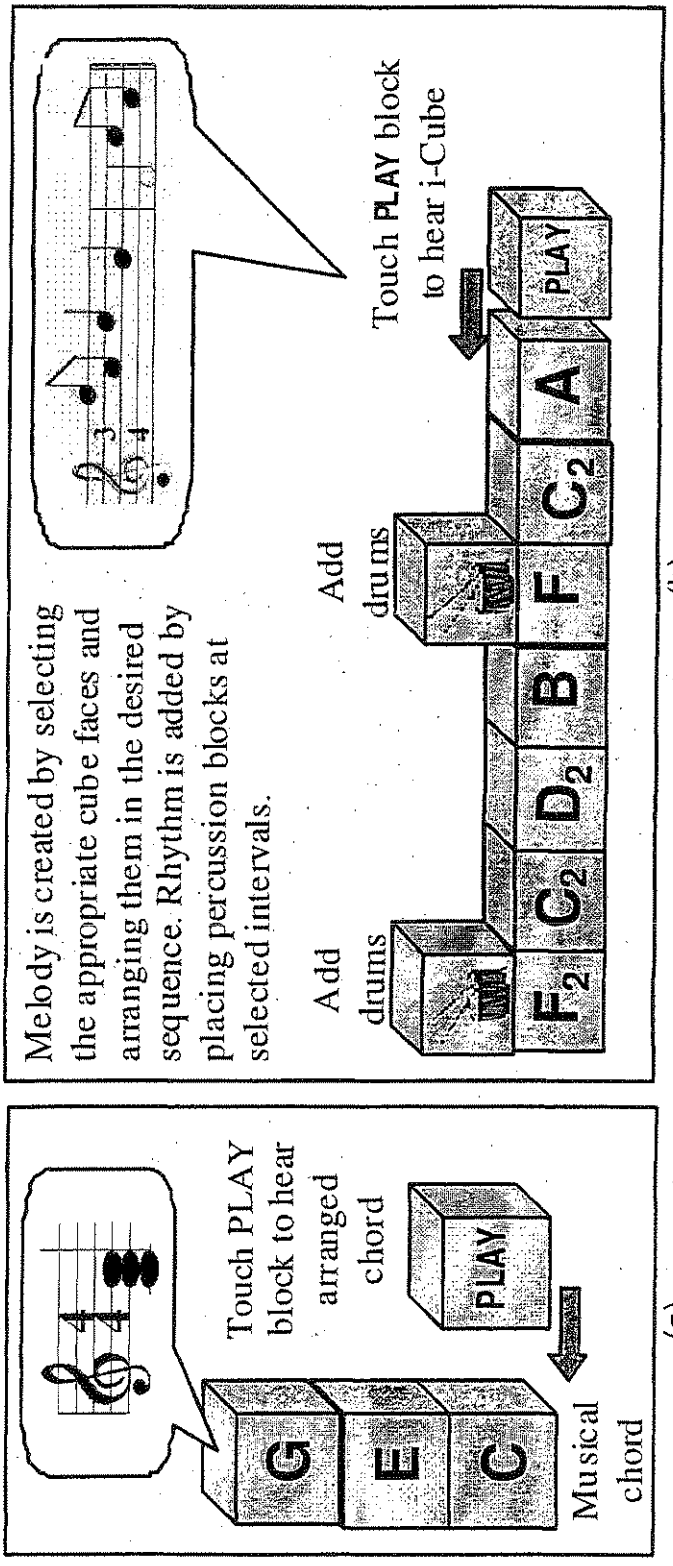

Melody is created by selecting the appropriate cube faces and arranging them in the desired sequence. Rhythm is added by placing percussion blocks at selected intervals.
Add drums
Touch PLAY block to hear i-Cube
PLAY
Add drums
Touch PLAY block to hear arranged chord
PLAY
Musical chord
(a)
(b)

Fig. 15

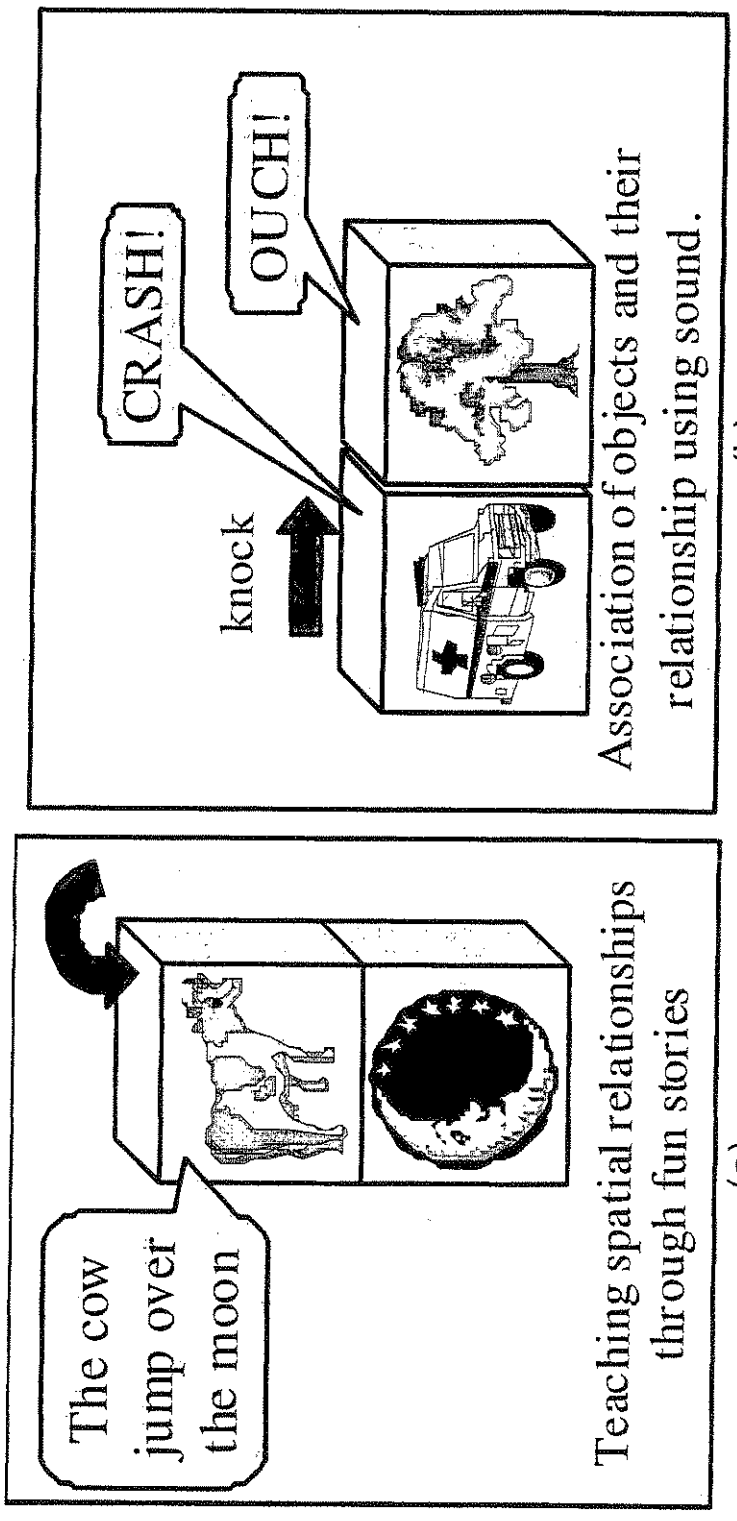

The cow jump over the moon
Teaching spatial relationships through fun stories
(a)
CRASH!
OUCH!
knock
Association of objects and their relationship using sound.
(b)

Fig. 16

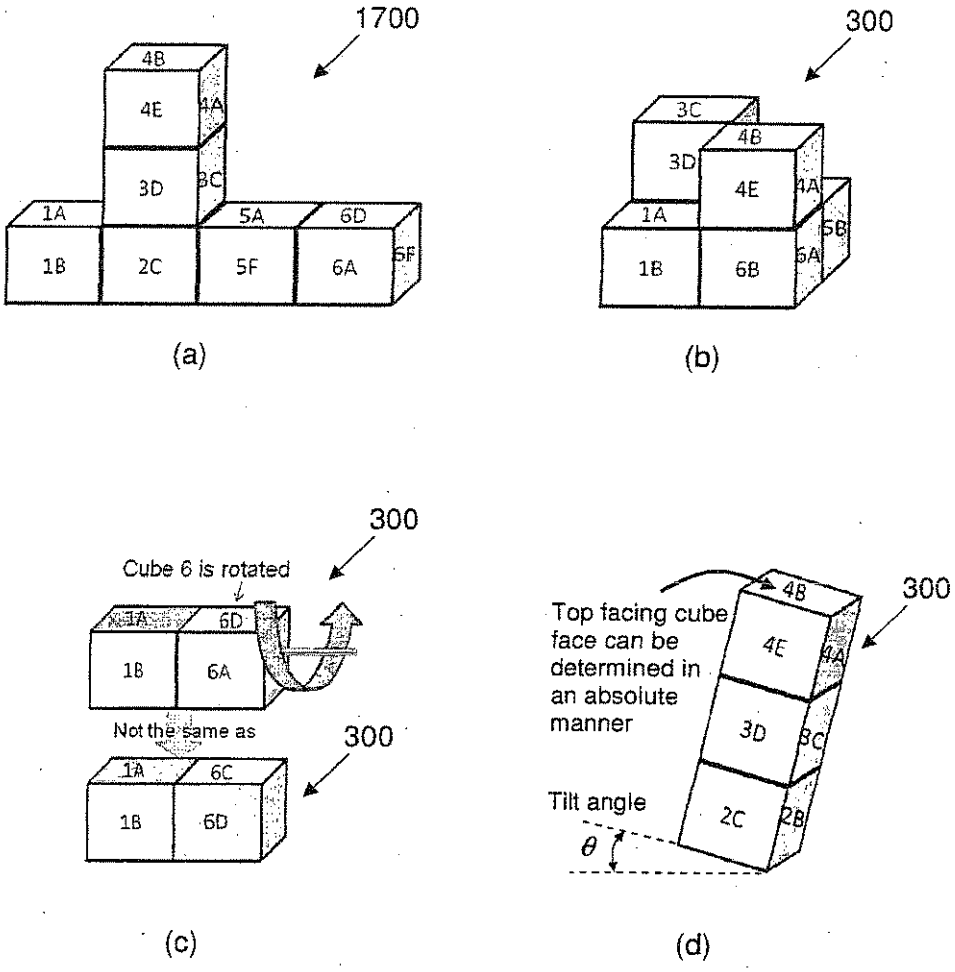

1700
4B
4E
4A
3D
3C
1A
5A
6D
1B
2C
5F
6A
5F
(a)
300
3C
4B
3D
4E
4A
1A
5B
6A
1B
6B
(b)
300
Cube 6 is rotated
1A
6D
1B
6A
Not the same as
300
1A
6C
1B
6D
(c)
Top facing cube face can be determined in an absolute manner
Tilt angle
θ
300
4B
4E
4A
3D
3C
2C
2B
(d)

Fig. 17