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Crucial Design Issues for Special Access Technology

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Crucial Design Issues for Special Access Technology; A Delphi Study

Pearl O' Rourke, Dr. Ray Ekins, Mr. Bernard Timmins, Prof. Fiona Timmins, Ms. Siobhan Long and Prof. Eugene Coyle

> Background and Significance

> Goal and Objectives

> Research Design

> Key Results

> Conclusions

> Background and Significance

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DISABILITY

> 15% of the population*

> The Social Model of Disability**

> Barriers hinder participation

*World Health Organisation (2011)
**Oliver & Sapey (2006)

ASSISTIVE TECHNOLOGY

> Helps people to overcome barriers to independence, participation and activity accomplishment.*

> When used appropriately, AT can improve quality of life.**

> AT ranges in complexity and functionality.

*Hersh & Johnson (2008)
**National Council on Disability (1993),
Pennsylvania's Initiative on Assistive Technology (1995)

> Problems

> **High costs** hinder access to AT.*

*Alper & Raharinirina (2006) and Taylor (2004)

> **30-80%** of AT is **abandoned.****

*Riemer-Reiss & Wacker (2000) and Philips & Zhao (1993)

* Alper & Raharinirina (2006) and Taylor (2004)

**Riemer-Reiss & Wacker (2000) and Philips & Zhao (1993)

> Cause

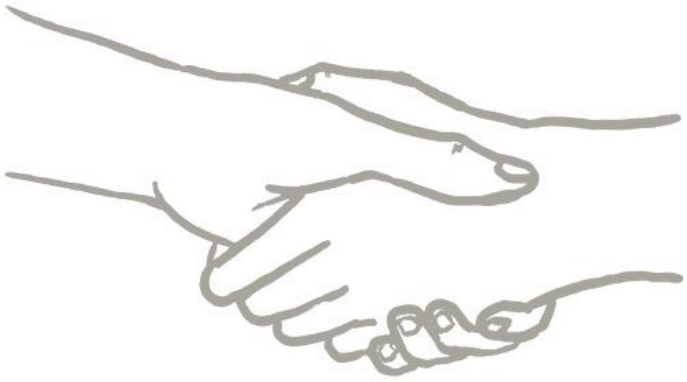
> Poor product design.*

*Philips & Zhao (1993), Gitlin (1995), Luborsky (1993), Kintsch and dePaula (2002).

> Solutions

> Universal design*
(by mass customisation).**

> User Involvement in the design process.***



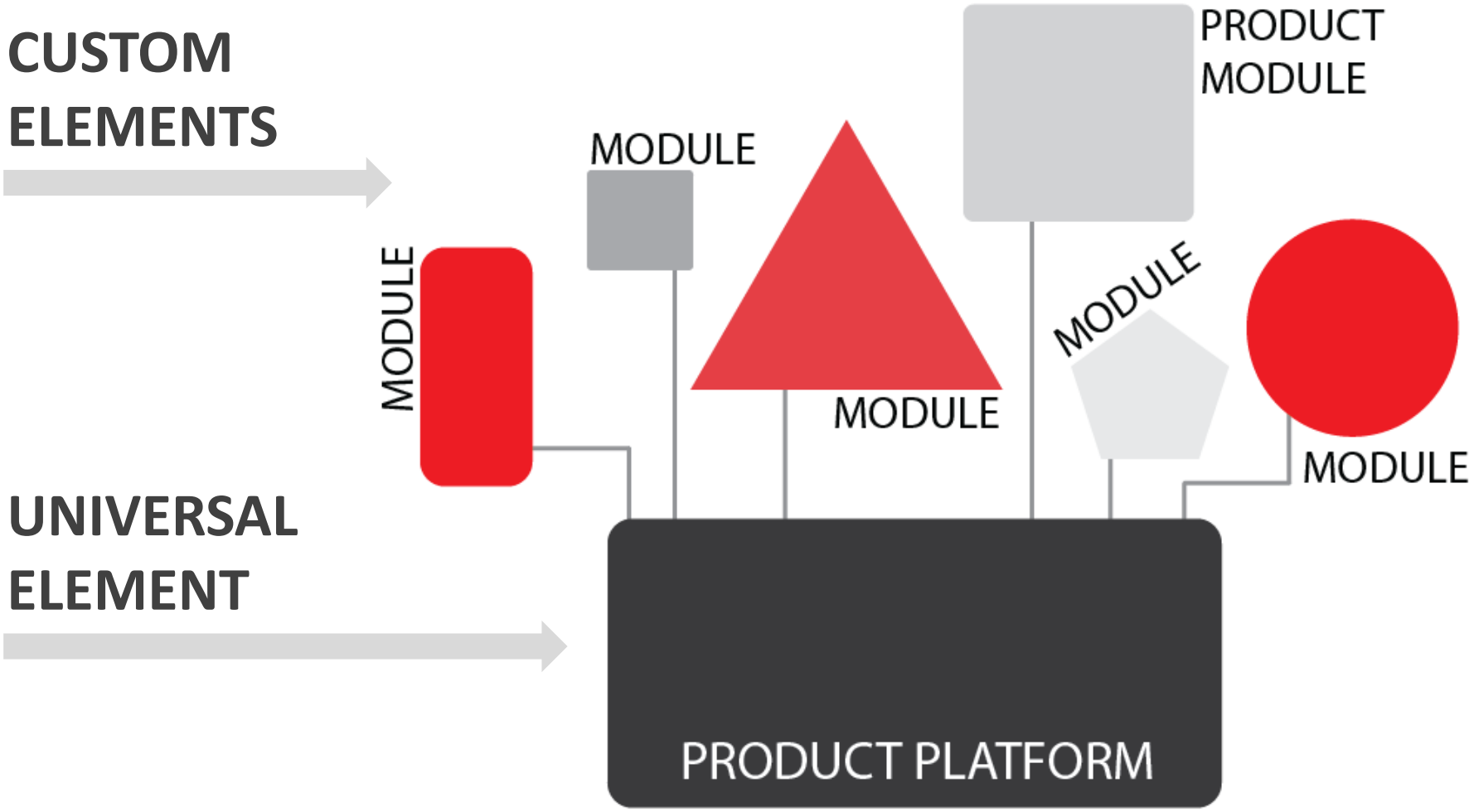
*Hersh (2011)
**Robinson et al. (2009)
***Bridgelal Ram et al. (2008)

> Mass Customisation

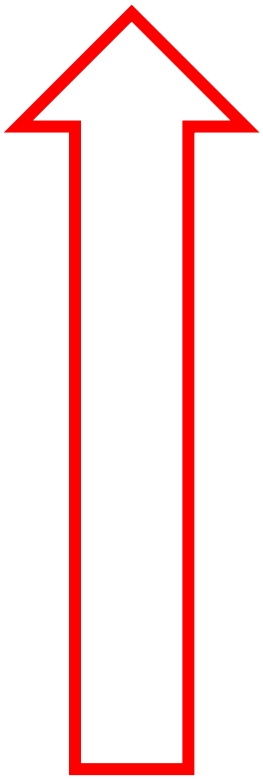
> **Aims to provide customised products at mass production prices*.**

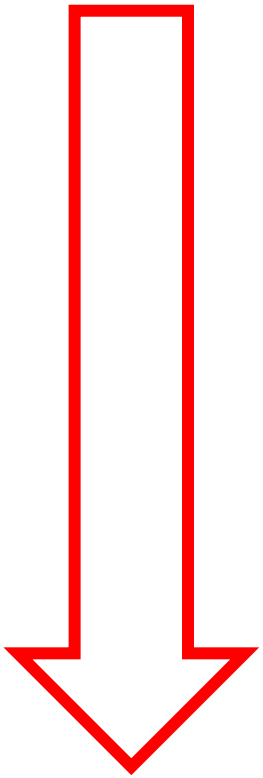
> **Mass customisation is based on modular product architectures...**

*[12] Pine (1993)


CUSTOM ELEMENTS
UNIVERSAL ELEMENT
MODULE
MODULE
MODULE
PRODUCT MODULE
MODULE
MODULE
PRODUCT PLATFORM

MORE FLEXIBILITY





LESS COST

> Background and Significance

> Goal and Objectives

> Research Design

> Key Results

> Conclusions

> The Gap and Goal

GAP

GOAL

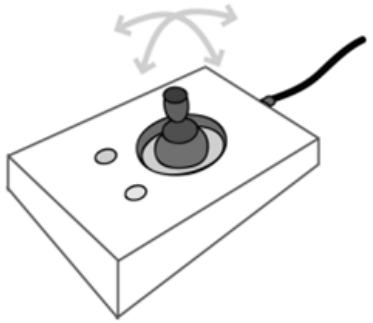
> Methods for designing customisable AT are not available, nor are clear processes for involving a variety of stakeholders in their design.*

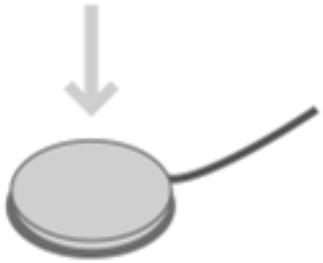
> The goal of this research is to develop a framework of **adaptable tools**, which **involve users**, to generate **actionable design specifications** for **customisable AT** devices...

...through the development of a new **Special Access Technology (SAT) device.**

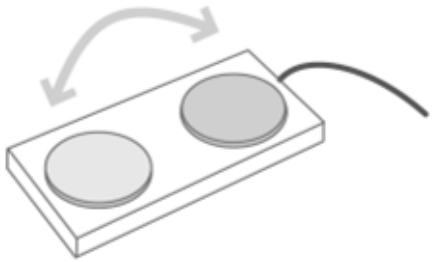
*Allsop (2010) and Bridgelal Ram et al. (2008)

> Special Access Technology





> Include **switches, joysticks, trackball and touch panels.**
> Present the problems of **high cost and abandonment.**
> Require more **universal** solutions.*



*Chen et al. (2006)






OFF/ON
















Bite Area






UP
DOWN
HEAD
FOOT
BED






> Background and Significance

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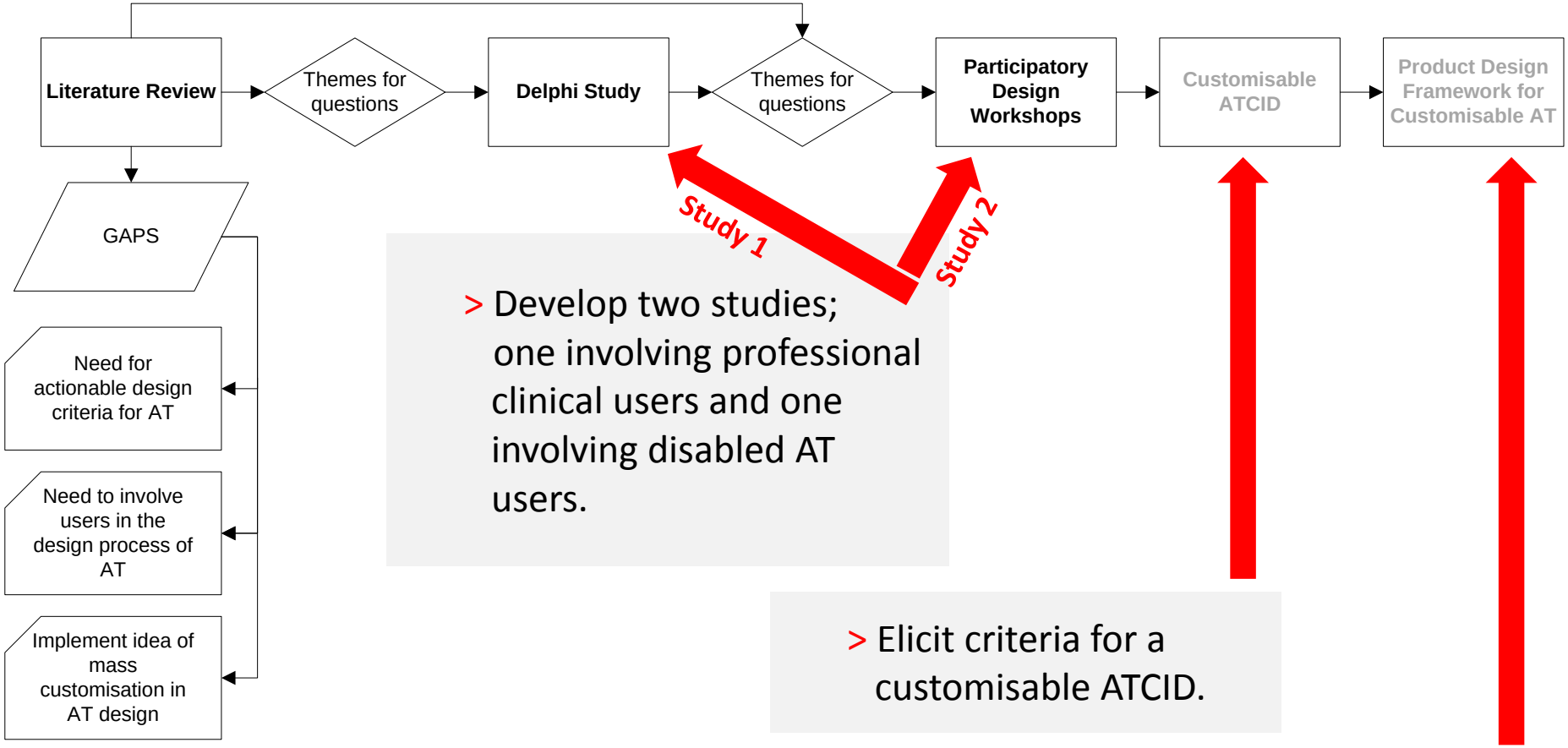
> Conclusions



Initial Design Framework

STUDY 1

Professionals working with people with disabilities

PRODUCT PLATFORM

Information Sheet

What's this all about?

You are invited to take part in a research study due to your professional experience and interaction with people who have motor/communicative impairments.

Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information. It is up to you to decide whether or not to take part.

STUDY 1

DELPHI STUDY

Ethics approval: June 2011

Study duration: Sep-Dec 2011

For individuals with severe motor and communication impairments, computer [illegible] are examples of such computers.

For individuals who cannot use a standard keyboard and mouse, scanning software may be accessed via AT devices such as switches, joysticks, trackballs and head-pointers. The design and functionality of these items vary vastly as different devices aim to satisfy different needs. Products target relatively small, niche markets and this leads to high costs being placed on the funding body or, increasingly, the disabled client. Additionally, the outdated culture of obtrusive, cold and clinical aesthetics has been found to inflict a stigmatising effect on the service-user. Subsequently there is a high rate of abandonment associated with generic products on the market.

The large and varied array of people involved in the provision and use of AT products further makes it difficult to get the balance of design solution correct. Stakeholders may include the service-user and their carer, a rehabilitation engineer, an occupational therapist, a speech therapist, a physiotherapist and a doctor. Others who may contribute include psychologists, educationalists and, perhaps, fund-holders.

User-centred design aims to create products that fit well with the user instead of forcing them to change the way they act in order to utilize the product. The approach involves users in the whole design process in order to match the product to the requirements and to increase practical use. This initial questionnaire based study aims to reach a consensus on professional opinion about the important qualities of assistive technology computer input devices. Subsequently, a device will be prototyped and a piece of research involving service-users will take place.

How you can help

The research method used here will be the Delphi method, a technique used to formulate group consensus from an expert panel. It will be composed of two questionnaires and will call for a combined time commitment of up to one and a half hours. The first should take about 45 minutes to complete. You will be asked seven short questions related to you and your experience and six longer questions about certain aspects of AT. You will be contacted in five to six weeks to complete the second questionnaire, which will be developed from the results of the first.

If you take part, you will;

- contribute to a new body of important and applicable information on AT in Ireland,
- help identify key criteria for AT computer input devices,
- aid in the design of a new, low-cost computer input device for individuals with motor and communicative impairments, and
- upon completion of the study, receive a summary of the findings.

Extra Information

Due to the nature of the Delphi method, your responses will be anonymous and of equal value to other participants'. A code will be assigned to you for the purpose of tracking received questionnaires and will be used in subsequent mailings. The code list linking your name to your code will be secured in an encrypted file and a hard copy will be stored in a secure locker. Your name will be deleted from the code list when your final questionnaire is received or if you decide to withdraw from the study. At such point, all information provided will become anonymous.

Should you require any further information on the study or your participation, please do not hesitate to contact the researcher. Details are on the consent form. This study is funded by the Irish Research Council for Science and Technology.

Thank you for your time and consideration.

References

1. Bradley N, Poppen W. Assistive technology, computers and internet may decrease sense of isolation for homebound elderly and disabled persons. Technology and Disability. 2003;15(1):19-25.
2. Houlihan BV, Brainoni ML, Warner G, Nesathurai S, Wierbicky J, Williams S. The impact of internet access for people with spinal cord injuries: A descriptive analysis of a pilot study. Disability and Rehabilitation. 2003;25(8):422-31.
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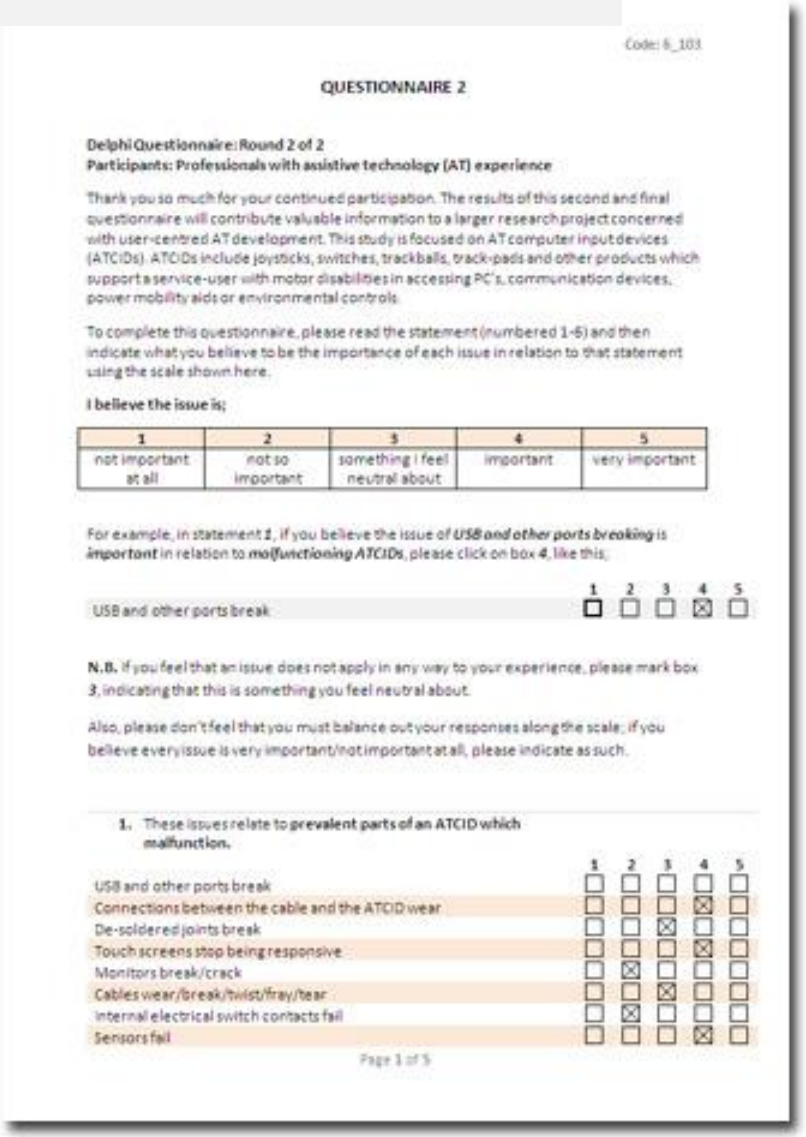
4. Wong AWK, Chan CCH, Li-Tsang CWP, Lam CS. Competence of people with intellectual disabilities on using human-computer interface. Research in Developmental Disabilities. 2009;30(1):107-23.
5. Davies TC, Mudge S, Ameratunga S, Stott NS. Enabling self-directed computer use for individuals with cerebral palsy: A systematic review of assistive devices and technologies. Developmental Medicine and Child Neurology. 2010;52(6):510-6.
6. Lubarsky MR. Sociocultural factors shaping technology usage: Fulfilling the promise. Technology and Disability; 1993. p. 71-8.
7. Buurman RD. User-centered design of smart products. Ergonomics. 1997;40:1159-69.

> Delphi questions

1	**Prevalent parts of ATCIDs that malfunction.**	*Problems that require attention*
2	**Primary reasons for ATCID malfunction.**	*Reasons for these problems*
3	**Characteristics of client associated with ATCID selection.**	*Highlights features which need to be customisable*
4	**Client needs regarding ATCID use and training.**	*Ideas to enrich whole product package*
5	**Desirable traits of ATCIDs.**	*Overarching criteria for design specification*
6	**Clinicians' frustrations with ATCIDs.**	*Real-life use contexts*

> 2nd Delphi questionnaire



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QUESTIONNAIRE 2

Delphi Questionnaire: Round 2 of 2
Participants: Professionals with assistive technology (AT) experience

Thank you so much for your continued participation. The results of this second and final questionnaire will contribute valuable information to a larger research project concerned with user-centred AT development. This study is focused on AT computer input devices (ATCIDs). ATCIDs include joysticks, switches, trackballs, track-pads and other products which support a service-user with motor disabilities in accessing PC's, communication devices, power mobility aids or environmental controls.

To complete this questionnaire, please read the statement (numbered 1-6) and then indicate what you believe to be the importance of each issue in relation to that statement using the scale shown here.

I believe the issue is;

1	2	3	4	5
not important at all	not so important	something I feel neutral about	important	very important

For example, in statement **1**, if you believe the issue of ***USB and other ports breaking*** is ***important*** in relation to ***malfunctioning ATCIDs***, please click on box **4**, like this;

	1	2	3	4	5
USB and other ports break	☐	☐	☐	☒	☐

N.B. If you feel that an issue does not apply in any way to your experience, please mark box **3**, indicating that this is something you feel neutral about.

Also, please don't feel that you must balance out your responses along the scale; if you believe every issue is very important/not important at all, please indicate as such.

1. These issues relate to prevalent parts of an ATCID which malfunction.

	1	2	3	4	5
USB and other ports break	☐	☐	☐	☐	☐
Connections between the cable and the ATCID wear	☐	☐	☐	☒	☐
De-soldered joints break	☐	☐	☒	☐	☐
Touch screens stop being responsive	☐	☐	☐	☒	☐
Monitors break/crack	☐	☒	☐	☐	☐
Cables wear/break/twist/fray/tear	☐	☐	☒	☐	☐
Internal electrical switch contacts fail	☐	☒	☐	☐	☐
Sensors fail	☐	☐	☐	☒	☐

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Code: 6_103

Fuses have defects	☐	☒	☐	☐	☐
Devices have calibration problems or are difficult to calibrate	☐	☐	☐	☐	☒
Conflicts exist between the computer and ATCID driver	☐	☐	☐	☒	☐
Software becomes corrupted (e.g. curser on screen moves without deflection of joystick)	☐	☐	☒	☐	☐
Movement of ATCID becomes restricted due to dirt build up	☐	☐	☒	☐	☐
Keys/buttons lift away from ATCID	☐	☒	☐	☐	☐
Switches stick in a closed/open position	☐	☐	☒	☐	☐
Lightweight switches are continuously accidentally activated and break	☐	☐	☐	☐	☒
Small parts get lost (e.g. clamping screws)	☐	☐	☐	☐	☒
Plugs break	☐	☐	☒	☐	☐
Joysticks becomes loose	☐	☐	☐	☒	☐
Unexplained/unclear reasons cause device failure	☐	☐	☒	☐	☐
Magnetic devices interfere with controls	☐	☐	☐	☒	☐
Batteries fail	☐	☐	☐	☐	☒
Mounts become damaged	☐	☐	☐	☒	☐
Mounts loosen	☐	☐	☐	☐	☒

2. These issues relate to the reasons ATCIDs malfunction or fail.

	1	2	3	4	5
No articulating joint on USB connections	☐	☐	☒	☐	☐
Weak joints from cable to device	☐	☐	☐	☒	☐
Poor ergonomic design	☐	☐	☒	☐	☐
Battery life/charge is insufficient	☐	☐	☐	☒	☐
Battery fails	☐	☐	☐	☒	☐
Memory board (i.e. central processing unit of host computer) fails	☐	☒	☐	☐	☐
Software updates conflict with device drivers	☐	☐	☒	☐	☐
Electrical components short circuit	☐	☐	☒	☐	☐
ATCID falls/is knocked or banged	☐	☐	☐	☐	☒
Inappropriate/rough/over use of device	☐	☐	☐	☐	☒
General wear and tear (i.e. ATCID is not robust enough)	☐	☐	☐	☒	☐
Cables get caught or are pulled roughly from ports	☐	☐	☐	☒	☐
Constant activation of a device with force	☐	☐	☒	☐	☐
Movement of client causes stress on the ATCID	☐	☒	☐	☐	☐
Movement of client causes mounts to loosen	☐	☐	☐	☒	☐
Lack of policy in relation to regular service of ATCIDs	☐	☐	☒	☐	☐
Poor maintenance of ATCID	☐	☐	☒	☐	☐
Poor care of ATCID when not in use (e.g. during transport)	☐	☐	☐	☒	☐
Poor battery conditioning practice	☐	☐	☐	☒	☐
Incorrect device set-up by carers	☐	☐	☐	☐	☒
Poor routing of cables exposing them to damage	☐	☐	☒	☐	☐
Dirt, spills and dust contamination	☐	☐	☐	☒	☐

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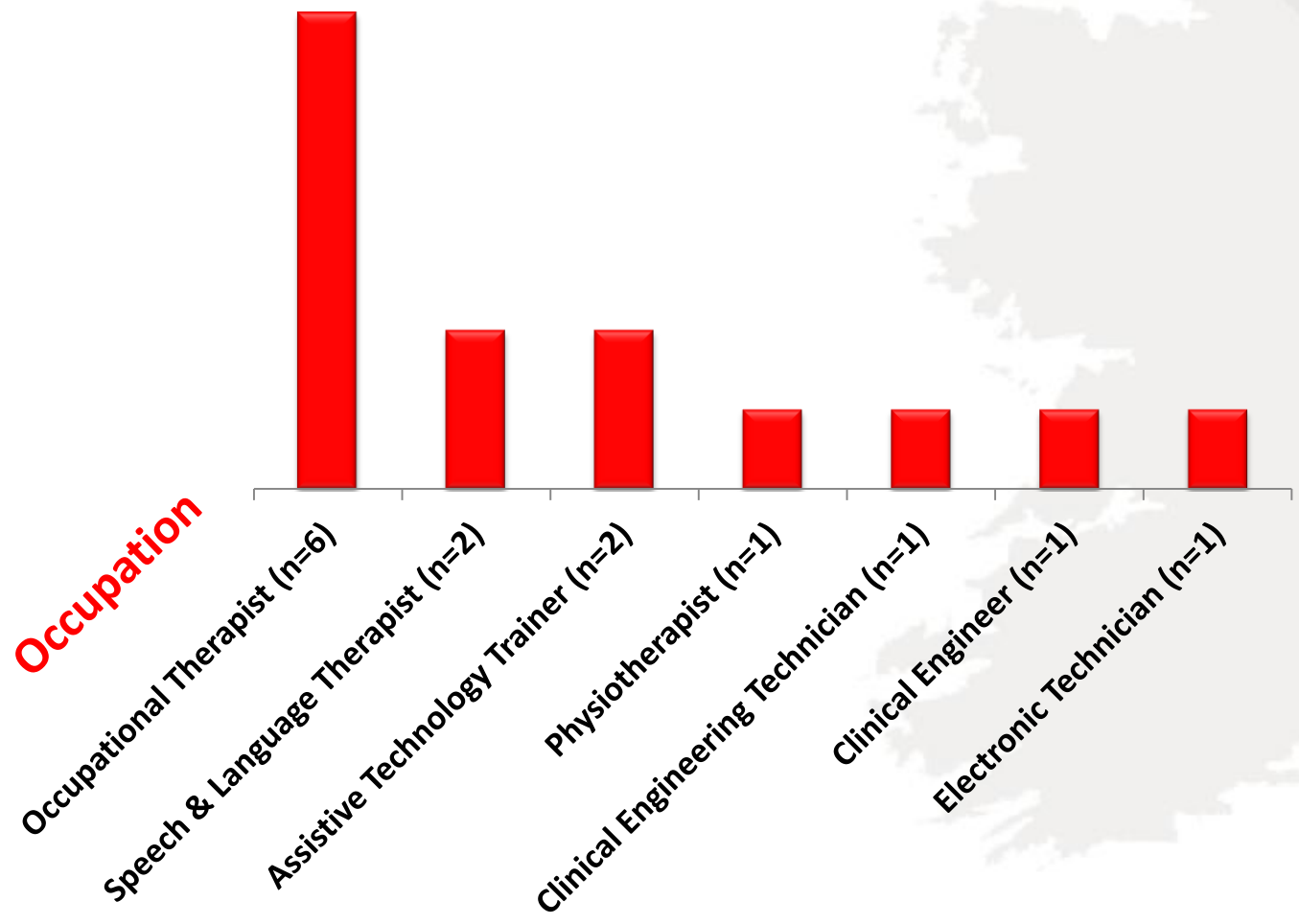


Place of Work

Northern Ireland (n=5)
36%

Republic of Ireland (n=9)
64%

> Ranked Responses

Delphi Study Results

Q1: ISSUES RELATING TO PREVALENT PARTS OF AN ATCID WHICH MALFUNCTION

The designer can now generate design solutions around each key issue.

Cables wear/break/twist/fray/tear
USB and other ports break
Internal electrical switch contacts fail
Sensors fail
Movement of ATCID becomes restricted due to dirt build up
Keys/buttons lift away from ATCID
Lightweight switches are continuously accidentally activated and break
Small parts get lost (e.g. clamping screws)
Mounts loosen
Switches stick in a closed/open position

Q2: ISSUES RELATING TO REASONS THAT CAUSE AN ATCID TO FAIL OR MALFUNCTION

The designer can now generate design solutions around each key issue.

ATCID falls/is knocked or banged
Cables get caught or are pulled roughly from ports
Weak joints from cable to device
Software updates conflict with device drivers
Movement of client causes mounts to loosen
Poor routing of cables, exposing them to damage
Dirt, spills and dust contamination
Poor care of ATCID when not in use (e.g. during transport)
Poor ergonomic design
Constant activation of a device with force

Q3: ISSUES RELATING TO CHARACTERISTICS OF A SERVICE USER ASSOCIATED WITH ATCID SELECTION

These criteria inform the designer about which elements need to be customisable.

Range of motion (i.e. of the anatomy which could control an ATCID)
Spasticity/muscle tone
Control of movement (i.e. ability to make precise movements)
Ability to repeat a movement without strain
Motivation and level of interest
Posture/positioning
Wrist/finger function (i.e. dexterity, sensory perception, proprioception)
Condition progression (improving/degenerating)
Type of wheelchair being used, if one is used
What the ATCID will be mounted on (plus requirements for clamps and mounts)

Q4: ISSUES RELATING TO SERVICE USER NEEDS REGARDING ATCID USE AND TRAINING

The designer can use this information to enrich the product package.

Correct positioning and mounting of the ATCID
Access to ATCIDs for trial period
Instilling the motivation to practice, explore and use the technology
Set-up of regular meetings with the service-user
Simple written instructions for ATCID set-up and use
Pictorial instructions for ATCID set-up and use
Maintenance and care instructions
How to adapt ATCID for the service user's changing needs
Contact details of supplier and technical support
Instilling confidence in the service-user

Q5: ISSUES RELATING TO DESIRABLE TRAITS FOR AN ATCID

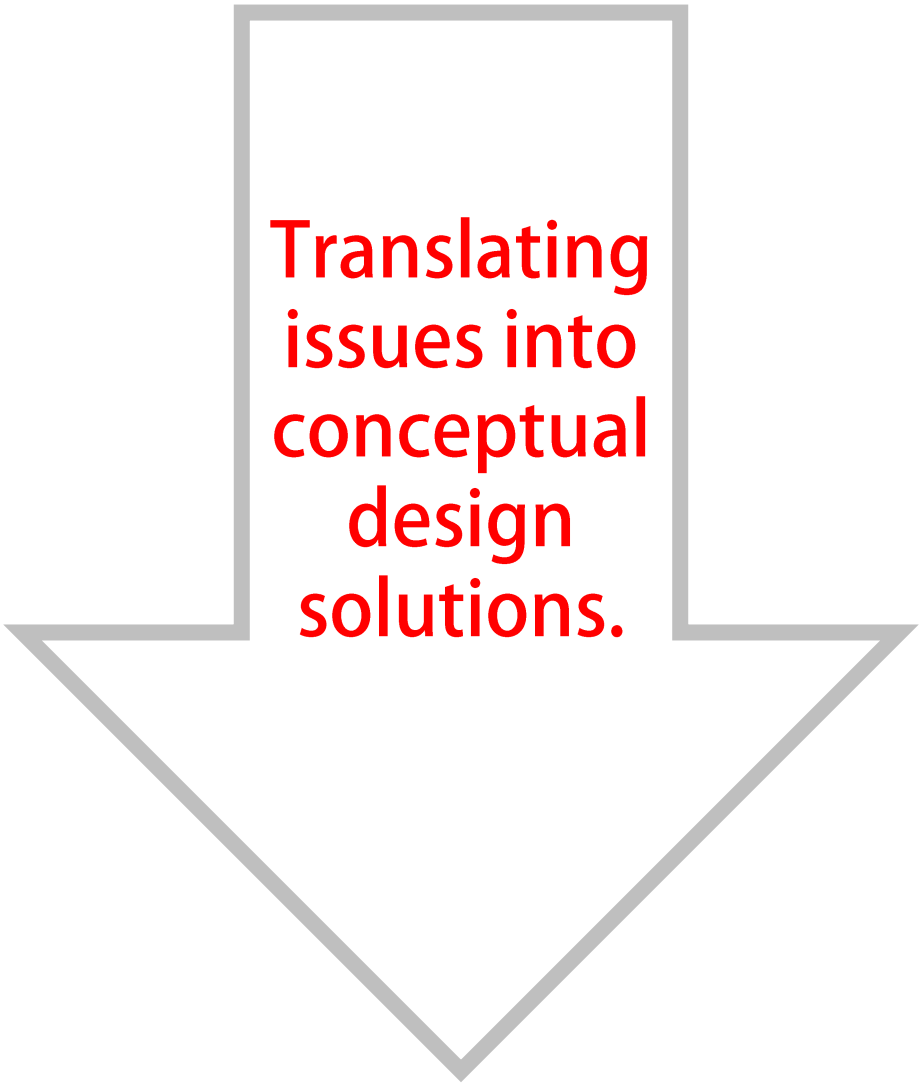
These provide the designer with building blocks for concept generation.

A good match between service-user's goals and ATCID solution
Comfortable to use/does not cause strain
Does not impede movement of service-user
Adaptable to service-user's specific needs
Easy to set up and dismantle
Easily rechargeable battery
Easy to operate
Appropriate size
Tactile characteristics
Low cost

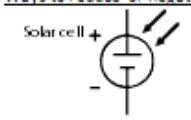
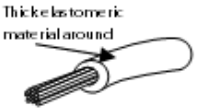
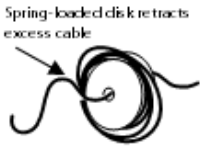
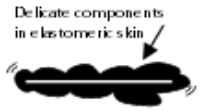
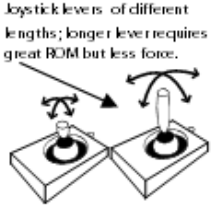
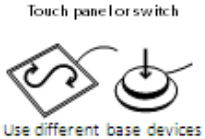
Q6: ISSUES RELATING TO PARTICIPANTS' FRUSTRATIONS ASSOCIATED WITH ATCIDS

This informs the designer about real-life contexts and their associated issues.

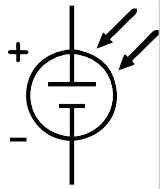
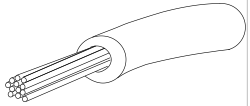
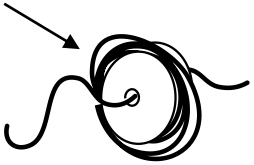
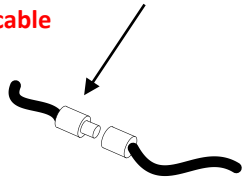
High cost of ATCIDs and access to funding for purchasing
Device drivers need to be loaded from CDs
System is not easily adaptable to suit exact service-user needs
Time needed to assess and train service-user
Products are specialist/niche; they should be mainstream/universal
USB connections are non-articulating/non-extended
Lack of instructions around decontamination procedures
Multiple parts need to be unscrewed and dismantled for decontamination
Positioning in multi care environment
Infection control


Translating
issues into
conceptual
design
solutions.

> Morphological Matrix

Design Issue	Relevant Component	Definition/Function	Design Solutions				
Question 1: These issues relate to prevalent parts of SAT which malfunction.			Ways to reduce or negate the design issue				
Cables wear/break/twist/fray/tear.	Cables	Transfer power and transfer signal.	 Take out cables & use wireless technologies (rechargeable batteries/ solar power/infrared transmitter and receiver).	 Use robust insulating materials to reduce likelihood of damage to cables.	 Make cables very rigid/flexible to reduce likelihood of torsion and breakage.	 Eliminate loose excess cable by retracting or winding/tucking it into a clip.	 Have purposeful 'breaking point' along cable which can be reconnected; cable is less likely to tear or damage ports and jacks at the computer interface.
Question 2: These issues relate to the reasons SAT malfunctions or fails.			Ways to reduce or negate the design issue				
SAT falls/is knocked or banged.	Housing/Casing	Protects internal components and affords aesthetic qualities to the product.	Protect SAT in robust casing.	Fix SAT on mount to reduce the likelihood of an accidental fall.	 Use a flexible material with low Young's modulus for casing to endure bangs.	Make all individual parts robust for disassembly, i.e. build in the ability for the SAT to be broken apart and easily put back together.	
Question 3: These issues relate to the characteristics of a user associated with selecting SAT.			Ways to make the product customisable with regard to the design issue				
Range of motion (ROM) of the anatomy which could control SAT.	Physical interface where human movement is required to activate device; joystick lever, switch button, trackball etc.	Distance hardware component needs to travel through to activate device.	Use various materials with different rigidity for adaptive customisation. (Work = Force X Distance)	 Forms requiring different activation distances.	 Use different base devices which require either a small ROM (touch-pad) or a large ROM (selection of switches).	Use an easily maneuverable mount which can position the SAT at various distances from the individual.	
Question 4: These issues relate to service-user needs regarding SAT use and training.			Ways to enrich the product package				
Correct positioning and mounting of the SAT.	Mount and mount-interface	How the therapist arranges the SAT in proximity to the user.	 Obviate need for mount - user wears SAT.	Provide an easily adjustable and re-adjustable mount. Use quick release levers and colour/number coded shafts.	Use shape memory alloys for mount material.		
Question 5: These issues relate to desirable traits of SAT.			Ways to enrich the product package				
A good match between disabled user's goals and SAT solution.	Whole product package	How well the SAT satisfies the user's goals.	Make the device adaptable/customisable.	Find out goals and provide solution using observation and team participation.	Use list of questions and tests to determine best SAT.	Provide a trialling period for new SAT.	Facilitate follow-up sessions and online feedback forums.
Question 6: These issues relate to your frustrations associated with SAT.			Ways to reduce or negate the frustration				
High cost of SAT and access to funding for purchasing	Whole product package	Monetary cost of the SAT.	Increase lifetime of product, i.e. build in the ability for the SAT to adapt with user's changing requirements.	Use off the shelf parts; examine other devices for component lists.	Increase market share by mass customisation or universal design.	Reduce overall cost of AT to the user by reducing abandonment.	Implement Design For Manufacture and Assembly guidelines (DFMA).

> Morphological Matrix

Design Issue	Relevant Part	Definition/ Function	Design Solutions				
Question 1: These issues relate to prevalent parts of SAT which malfunction.			***Ways to reduce or negate the design issue***				
Cables wear/break/twist/fray/tear.	Cables	Transfer power and transfer signal.	**Solar cell**  Take out cables & use wireless technologies (rechargeable batteries/ solar power/infrared transmitter and receiver).	**Thick elastomeric material around wire cable**  Use robust insulating materials to reduce likelihood of damage to cables.	 Make cables very rigid/flexible to reduce likelihood of torsion and breakage.	**Spring-loaded disk retracts excess cable**  Eliminate loose excess cable by retracting or winding/tucking it into a clip.	**Port and jack along cable**  Have purposeful 'breaking point' along cable which can be reconnected; cable is less likely to tear or damage ports and jacks at the computer interface.

> Background and Significance

> Goal and Objectives

> Research Design

> Key Results

> Conclusions

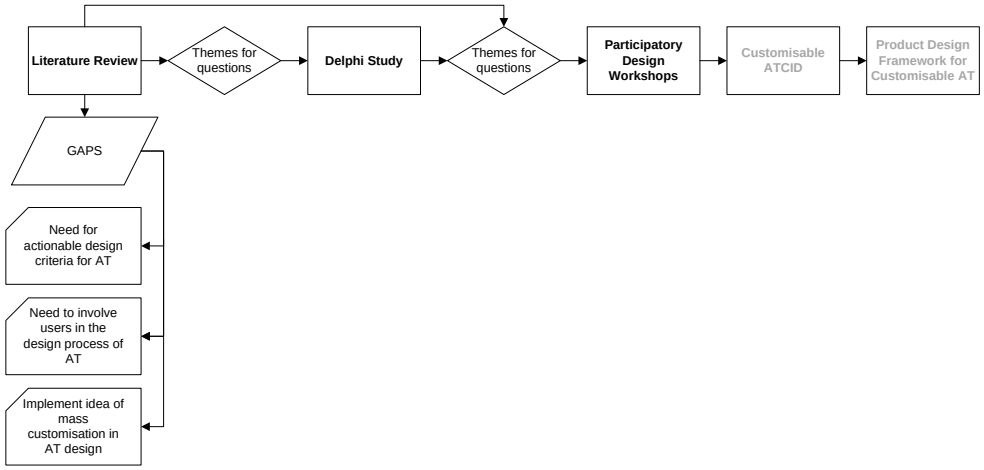
IMPLICATIONS

> This method supports the development of new, low-cost AT products, which satisfy a broad range of consumers' needs.

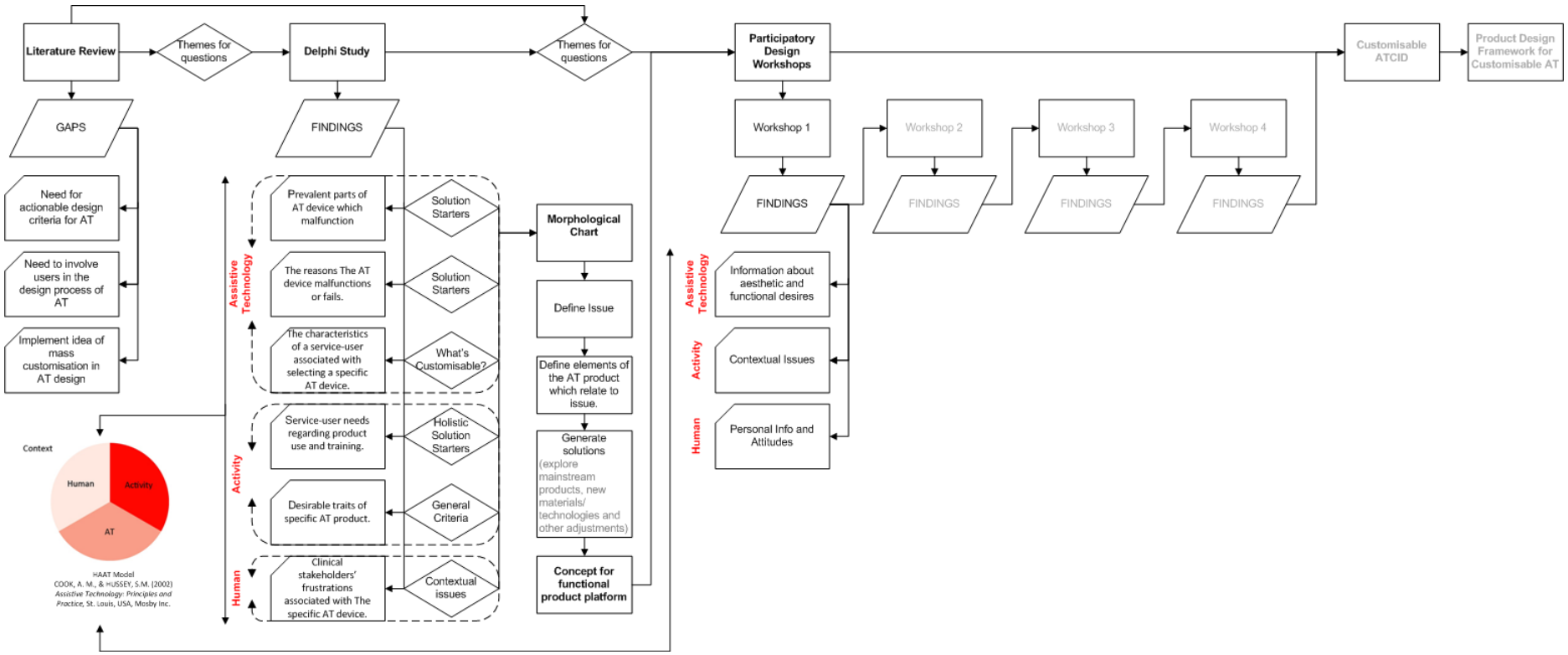
> It structures the establishment of consensus on crucial design issues for a specified AT domain, and subsequently facilitates the application of these issues to the product design process.

> This research presents crucial design issues for the SAT domain, in order to assist future work.

> This research supports and provides validation for past studies about desirable criteria for AT.



Design framework and future work



Design framework and future work

Many Thanks.

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