Concepts and Modelling Techniques for Pervasive and Social Games

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Agenda

- Introduction
  - Problem Statement
  - Research Questions and Challenges
  - Research Contributions
  - Research method
- RC1: TeMPS
  - Introduction
  - State of art
  - Evaluation
- RC2: PerGO
  - Introduction
  - State of art
  - Evaluation
- RC3: GCCT
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- Conclusion and Future work
  - Research Method
  - TeMPS
  - PerGO
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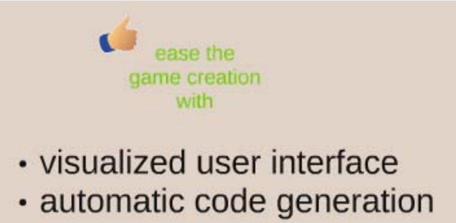
Problem Statement

- Pervasive Game vs. Computer Game
- Features
  - Location-based
  - Physical user interfaces
  - Mobile devices
  - ...

Problem Statement

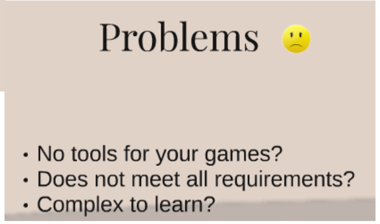
- Game Development Tools
  - Authoring tools
  - Engine tools

  - Customized authoring tools?



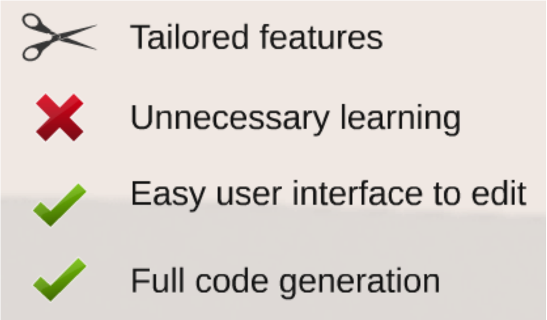
👍 ease the game creation with

- visualized user interface
- automatic code generation



Problems 🙁

- No tools for your games?
- Does not meet all requirements?
- Complex to learn?



✂ Tailored features

✗ Unnecessary learning

✓ Easy user interface to edit

✓ Full code generation

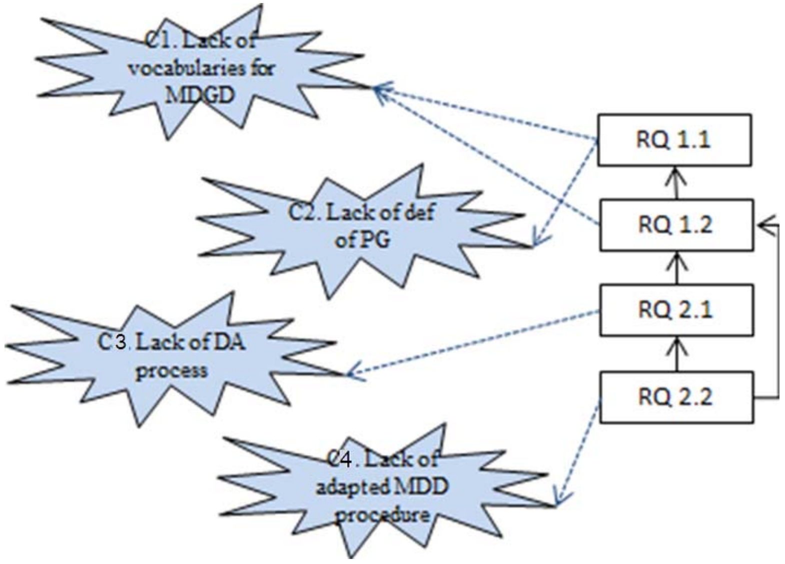
Problem Statement

- Model Driven Software Development (MDD)
  - Model as the primary artifact
  - Domain Specific Language (DSL), Domain Specific Modelling (DSM)
  - Code automation
- MDD for games
  - to implement customized tools?
    - conceptual challenges (base of reusing game domain knowledge in MDD)
    - procedural challenges (how to reuse domain knowledge and respect game development traditions in MDD)

Research Questions and Challenges

- *RQ1: What important concepts need to be considered regarding creating pervasive games with a model driven approach?*
  - *RQ1.1: What important characteristics should/ may a pervasive game have?*
  - *RQ1.2: What concepts can be used in a Domain Specific Language (DSL) of pervasive games?*
- *RQ2: How can MDSD techniques be applied in a traditional pervasive /computer game creation process?*
  - *RQ2.1: How can a formalized domain vocabulary be used to enhance the domain analysis process in order to create pervasive games with a DSM approach?*
  - *RQ2.2: How can a traditional computer game development process be adapted to support DSM tasks in an efficient and iterative way?*

- Lack of common vocabularies shared between computer (and pervasive) games for the purpose of applying MDSD (C1)
- Lack of a consolidated definition of pervasive game (C2)
- Lack of a structured domain analysis process to reuse domain knowledge efficiently (C3)
- Lack of consideration of computer game traditions when applying the MDSD process (C4)



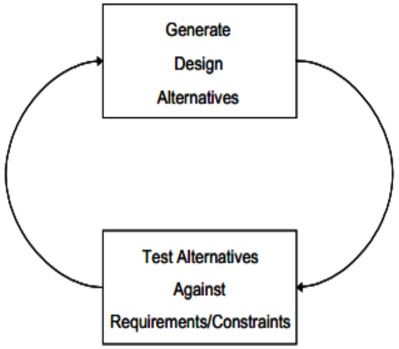
Research Contributions

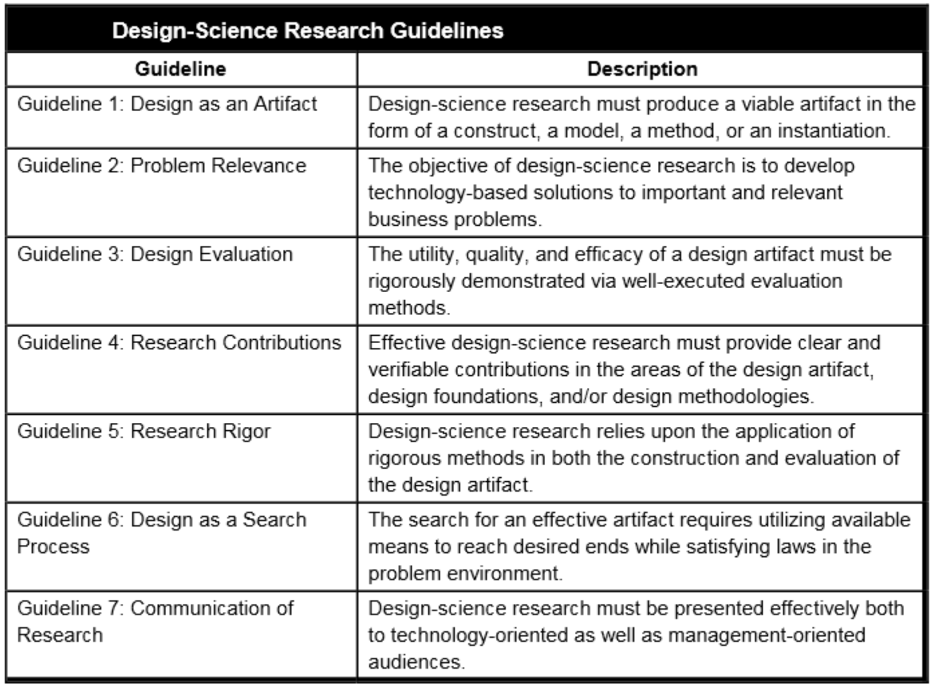
- RC1: A conceptual framework named **TeMPS** (meaning Temporality, Mobility, Perceptibility and Sociality) to summarize important characteristics of pervasive and social games.
- RC2: An ontology named **PerGO** (meaning Pervasive Game Ontology) to structure and accelerate domain analysis for model driven pervasive games development.
- RC3: A process named **GCCT** (meaning Game Creation with Customized Tools) to make use of model driven techniques within the traditional computer game development process.

	RQ1.1	RQ1.2	RQ2.1	RQ2.2
RC1	X			
RC2		X	X	
RC3			X	X

Research Methods

- Two paradigms in IS research:
  - *behavioural science – “truth”*
    - develops and verifies theories that explain or predict human behaviour or organization
  - *design science – “utility”*
    - improve or extend the capacities of man or organization by building new artefacts
- Design is both a process (activities) and a product (artefacts).


Generate Design Alternatives
Test Alternatives Against Requirements/Constraints



Design-Science Research Guidelines

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

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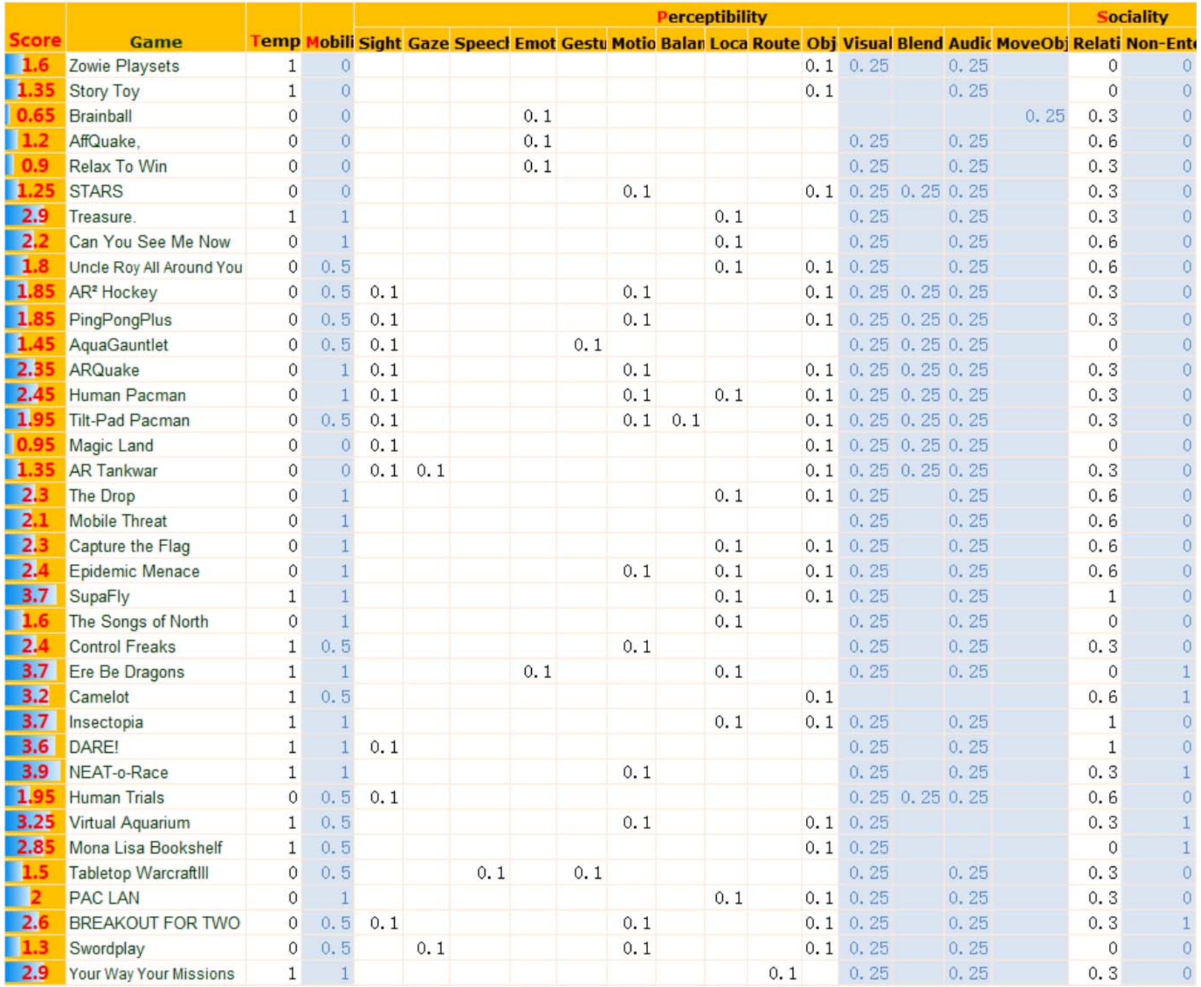
TeMPS

- a conceptual framework for characterizing pervasive games
- provides an approach to better understand
  - what are pervasive games and
  - what features we should consider when trying to develop such games
- serves as a base for the other research contributions of this thesis

TeMPS

- Temporality
  - addressing the game’s temporal property,
  - i.e. whether the game is played in a fixed time/round or not (open beginning and/or open ended);
- Mobility
  - addressing the spatial property,
  - i.e. whether the game could be played anywhere or whether it is fixed in one place;
- Perceptibility
  - addressing how the game is mixed with reality,
  - e.g. does the game construct the appearance of the player proxy in the game by sensing the player’s real world appearance? Does the player need to physically move to move virtually in the game?; And finally,
- Sociality
  - addressing the player’s relationship with and social influence of the game.

TeMPS: Evaluation



Score	Game	Temp	Mobili	Perceptibility														Sociality	
				Sight	Gaze	Speecl	Emot	Gestu	Motio	Balan	Loca	Route	Obj	Visual	Blend	Audic	MoveObj	Relati	Non-Ente
1.6	Zowie Playsets	1	0										0.1	0.25		0.25		0	0
1.35	Story Toy	1	0										0.1			0.25		0	0
0.65	Brainball	0	0				0.1										0.25	0.3	0
1.2	AffQuake,	0	0				0.1							0.25		0.25		0.6	0
0.9	Relax To Win	0	0				0.1							0.25		0.25		0.3	0
1.25	STARS	0	0						0.1				0.1	0.25	0.25	0.25		0.3	0
2.9	Treasure.	1	1								0.1			0.25		0.25		0.3	0
2.2	Can You See Me Now	0	1								0.1			0.25		0.25		0.6	0
1.8	Uncle Roy All Around You	0	0.5								0.1		0.1	0.25		0.25		0.6	0
1.85	AR² Hockey	0	0.5	0.1					0.1				0.1	0.25	0.25	0.25		0.3	0
1.85	PingPongPlus	0	0.5	0.1					0.1				0.1	0.25	0.25	0.25		0.3	0
1.45	AquaGauntlet	0	0.5	0.1				0.1						0.25	0.25	0.25		0	0
2.35	ARQuake	0	1	0.1					0.1				0.1	0.25	0.25	0.25		0.3	0
2.45	Human Pacman	0	1	0.1					0.1		0.1		0.1	0.25	0.25	0.25		0.3	0
1.95	Tilt-Pad Pacman	0	0.5	0.1					0.1	0.1			0.1	0.25	0.25	0.25		0.3	0
0.95	Magic Land	0	0	0.1									0.1	0.25	0.25	0.25		0	0
1.35	AR Tankwar	0	0	0.1	0.1								0.1	0.25	0.25	0.25		0.3	0
2.3	The Drop	0	1								0.1		0.1	0.25		0.25		0.6	0
2.1	Mobile Threat	0	1											0.25		0.25		0.6	0
2.3	Capture the Flag	0	1								0.1		0.1	0.25		0.25		0.6	0
2.4	Epidemic Menace	0	1						0.1		0.1		0.1	0.25		0.25		0.6	0
3.7	SupaFly	1	1								0.1		0.1	0.25		0.25		1	0
1.6	The Songs of North	0	1								0.1			0.25		0.25		0	0
2.4	Control Freaks	1	0.5						0.1					0.25		0.25		0.3	0
3.7	Ere Be Dragons	1	1				0.1				0.1			0.25		0.25		0	1
3.2	Camelot	1	0.5										0.1					0.6	1
3.7	Insectopia	1	1								0.1		0.1	0.25		0.25		1	0
3.6	DARE!	1	1	0.1										0.25		0.25		1	0
3.9	NEAT-o-Race	1	1						0.1					0.25		0.25		0.3	1
1.95	Human Trials	0	0.5	0.1										0.25	0.25	0.25		0.6	0
3.25	Virtual Aquarium	1	0.5						0.1				0.1	0.25				0.3	1
2.85	Mona Lisa Bookshelf	1	0.5										0.1	0.25				0	1
1.5	Tabletop WarcraftIII	0	0.5			0.1		0.1						0.25		0.25		0.3	0
2	PAC LAN	0	1								0.1		0.1	0.25		0.25		0.3	0
2.6	BREAKOUT FOR TWO	0	0.5	0.1					0.1				0.1	0.25		0.25		0.3	1
1.3	Swordplay	0	0.5		0.1				0.1				0.1	0.25		0.25		0	0
2.9	Your Way Your Missions	1	1									0.1		0.25		0.25		0.3	0

Figure 68. Pervasive Games Reviewed by the TeMPS Framework

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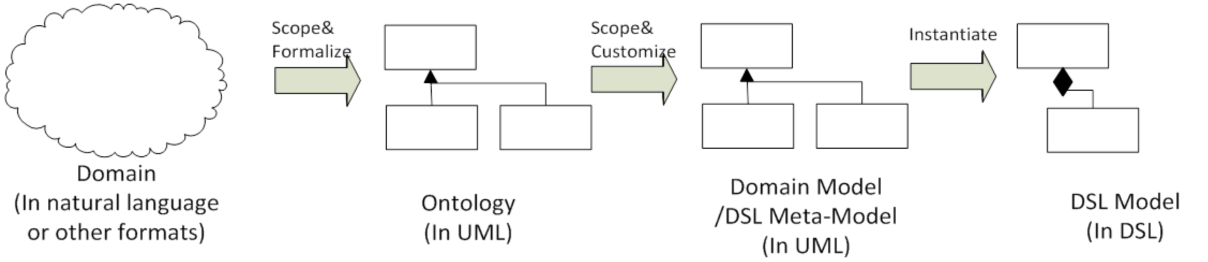
Pervasive Game Ontology (PerGO)

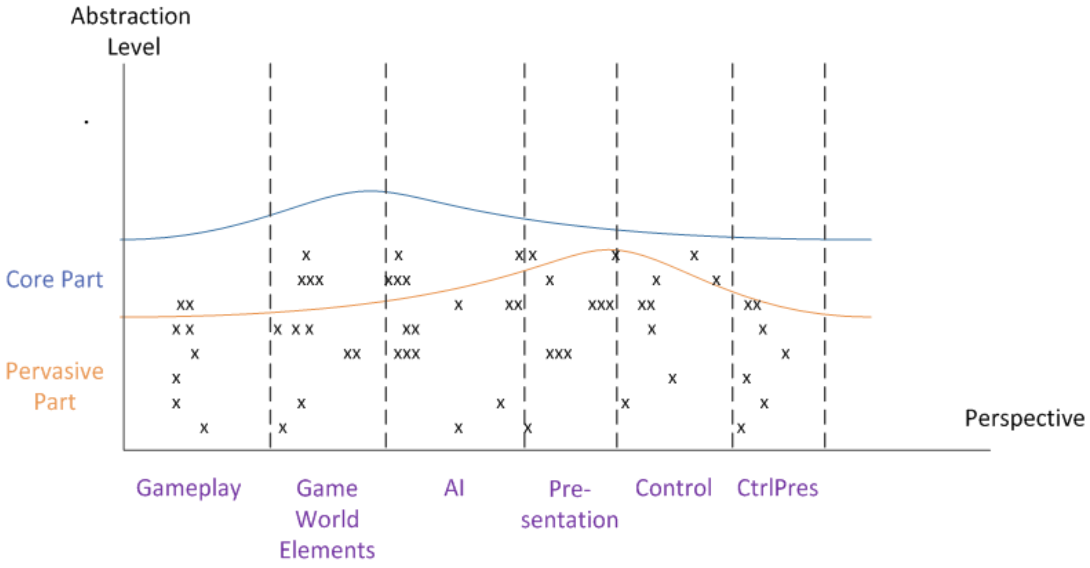
- PerGO includes:
  - A Domain Vocabulary
  - A Domain Analysis Procedure
- PerGO is based on
  - an understanding of pervasive games (through TeMPS) and
  - general requirements from model driven techniques
- PerGO is the basis of the domain analysis part in the GCCT approach.



The expected progression from domain knowledge to DSL models.

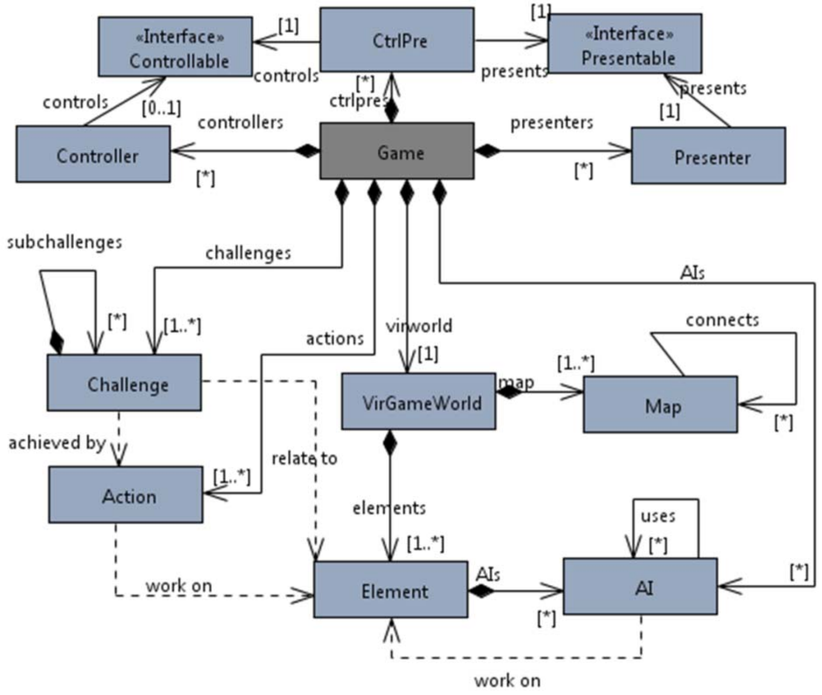
- Firstly, an ontology (PerGO) is used to formalize the common domain knowledge for pervasive games.
- Then DSL meta-models are constructed by customizing the ontology for the more specific domains like pervasive treasure hunting games
- When the DSL is ready to use, it will be possible to write specifications (DSL model) using the DSL. Such specifications are instances of the corresponding domain model (DSL meta-model) and can be used to generate game software by utilizing MDSD tools.

PerGO: Structure

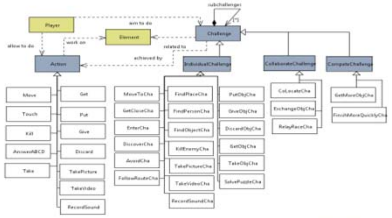


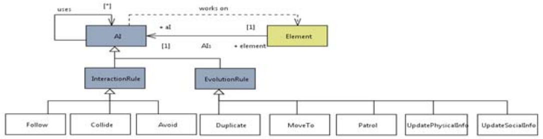
- In total more than 100 concepts
- Concepts are organized into 6 perspectives which focus separately on different aspects of game software.
- Two levels of concepts:
    - high-level concepts which are common to all computer games and
    - low-level concepts which are specific to pervasive games (primarily used or often used by pervasive games)
    - low-level concepts are derived from the high-level concepts

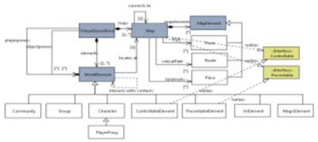
PerGO: Core Part and Pervasive Part

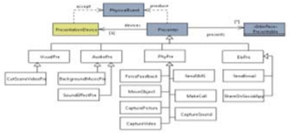


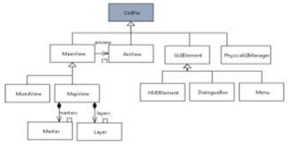
- Perspectives:
  - *Gameplay* perspective
  - *Artificial Intelligence (AI)* perspective
  - *GameWorldElement*
  - *Control*
  - *Presentation*
  - *CtrlPresentation*

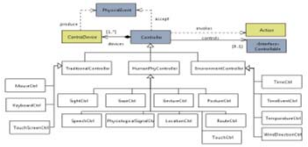












PerGO: DA Procedure

- The four steps proposed are:

1) Quickly identify perspectives that are related to the current domain, and record them in the first column;
2) Go through the perspectives in the first column. For each one, consider the corresponding common game design, then select useful concepts from PerGO or derive more specific concepts for the domain based on PerGO to represent this design. Record the concepts in the second column, in case there is more detailed information, especially attributes corresponding to the concepts, and record them in the third column;
3) Similarly to step 2), go through the perspectives in the first column. This time, consider the variable game design that may be used in different game samples. Decide whether some other concepts (within PerGO or newly invented) are needed besides those that have been listed in the second column, and add them if this is the case;
4) Go through all of the concepts in the second column, and decide how to utilize attributes of them or relationships among them to support the variable game design. Then write them in the last column.

Perspective	Concept	Commonality Details	Variability Details

PerGO: Related Work

	Literature							
	A	B	C	D	E	F	G	H
Formal DA Methods								
Structured DA/DD	*	s	s	s				
Pre-defined Vocabulary	*	s						
Full-spectrum Vocabulary	*	*						
DSL (Not GPL)	*			*	*	*	*	*

A: (Furtado, Santos et al. 2010) (Furtado and Santos 2006) ((Furtado and Santos 2006, Furtado, Santos et al. 2011)) B: (Tang, Hanneghan et al. 2008) ((Tang and Hanneghan 2010), (Tang and Hanneghan 2011)) C: (Reyno and Cubel 2009) (Reyno and Carsí Cubel 2009) D: (Walter and Masuch 2011) E: (Maier and Volk 2008) F: (Moreno-Ger, Sierra et al. 2007) G: (Hernandez and Ortega 2010) H: (Funk and Rauterberg 2012)

PerGO: Evaluation

- (**Effectiveness**) The vocabulary should support the implementation of the domain specific features;
- (**Effectiveness**) The concepts within the vocabulary should be constructive and of proper abstraction level and complexity to support the implementation of DSM artefacts;
- (**Efficiency**) The domain analysis process should be reasonably ordered to solve the design dependencies/ constraints

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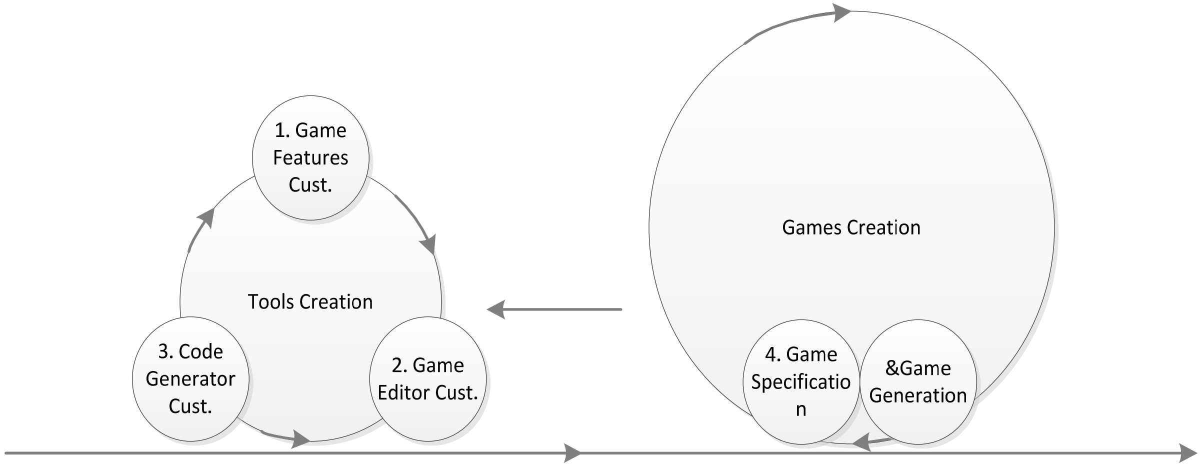
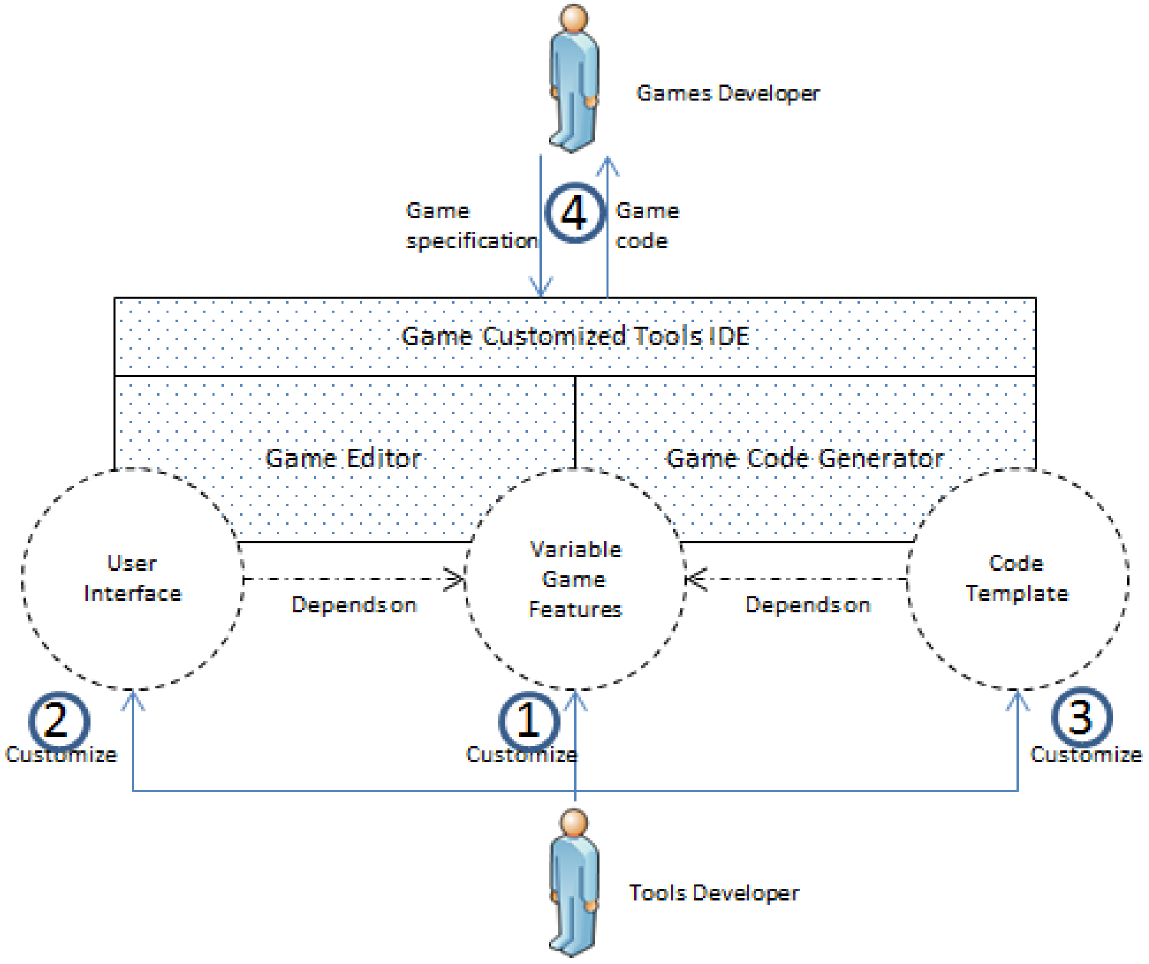
GCCT

- Game Creation with Customized Tools
  - create tools according to specific domain requirements, then
  - create games with these tools
- GCCT utilizes PerGO for the domain analysis part



GCCT

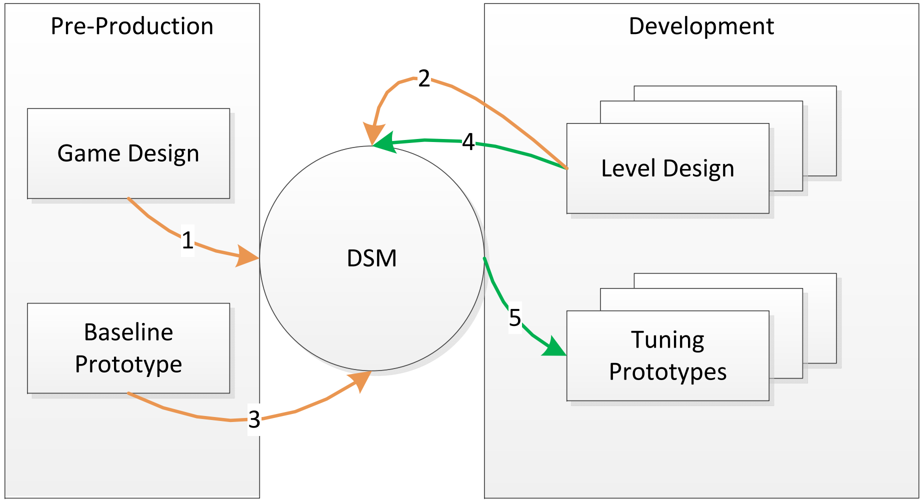

Games Developer
Game specification
4
Game code
Game Customized Tools IDE
Game Editor
Game Code Generator
User Interface
Depends on
Variable Game Features
Depends on
Code Template
2
Customize
1
Customize
3
Customize
Tools Developer

GCCT is Based on MDD

GCCT tasks		Corresponding MDD tasks
Tools Customization	1. Game feature Customization	1.1 Domain analysis according to project requirements 1.2 DSL meta-model/ abstract syntax definition based on domain analysis results
	2. Game Editor Customization	2.1 Style selection according to project requirements 2.2 DSL concrete syntax definition based on the DSL meta-model and the editor style
	3. Game Code Generator Customization	3.1 Code template definition based on the DSL meta-model and codes of a working prototype
4. Game Creation		4.1 Model creation based on the DSL 4.2 Code generation according to the model

GCCT is an Enhanced MDD Approach

- MDD has drawbacks:
  - Non-trivial (upfront and continuous) cost for tool development
  - High technical threshold
  - Resistance from the team due to such reasons
- Enhancements in GCCT to alleviate some drawbacks:
  - structure existing game tasks/ documents to produce domain analysis outputs
  - accelerate the domain analysis based on predefined domain vocabularies
  - reuse existing working prototypes to construct code generators
  - utilize the state of the art and highly integrated language workbench tools



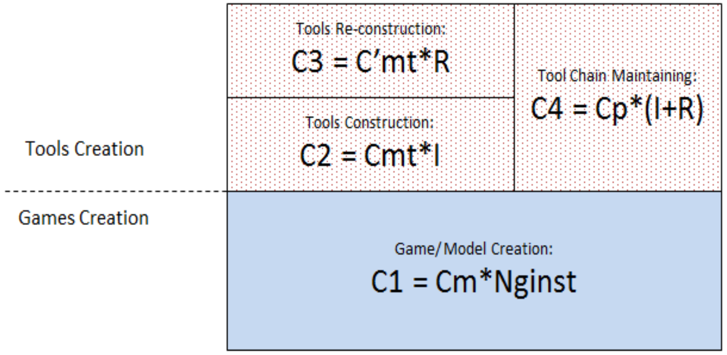
GCCT: Related Work

	Domain Analysis Approach	Adapted Process	Real Cost Data	Cost Structure Analysis	Usage Scenario (When)	Efficiency Tips (How)
(Furtado and Santos 2006, Furtado, Santos et al. 2010) ((Furtado and Santos 2006, Furtado, Santos et al. 2011))	Y	Y	Y	-	-	-
(Tang, Hanneghan et al. 2008) ((Tang and Hanneghan 2010), (Tang and Hanneghan 2011))	Y	-	-	-	-	-
(Reyno and Cubel 2008, Reyno and Carsí Cubel 2009)	-	Y	Y	-	-	-
(Walter and Masuch 2011)	-	Y	-	-	-	-
(Maier and Volk 2008)	-	Y	-	-	-	-
(Moreno-Ger, Sierra et al. 2007)	Y	Y	-	-	-	-
(Hernandez and Ortega 2010)	Y	-	Y	Y	-	-
(Zhang 2005)	Y	Y	Y	-	-	-
(Funk and Rauterberg 2012)	-	Y	-	-	-	-
GCCT	Y	Y	Y	Y	Y	Y

GCCT: Evaluation

Cost

- Empirical data
- Cost structure
- Practical lessons

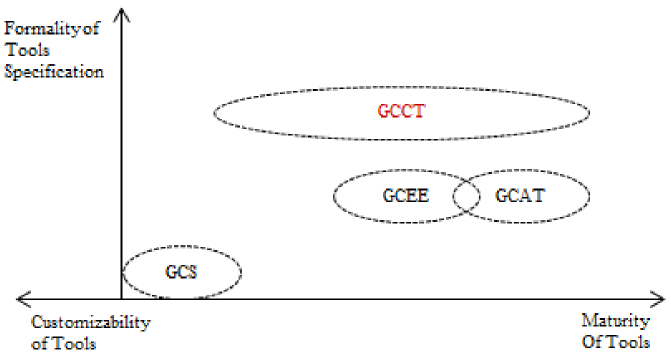


		RealCoins		RealPacman	
		Hrs	Percentage of Manual	Hrs	Percentage of Manual
GCS (Manual)		14	100%	8.267	100%
GCCT	Tools	11	78.6%	5.3	64.1%
	Game	0.75	5.4%	0.55	6.7%

		RealCoins		RealPacman	
		LoC	Percentage of Manual	LoC	Percentage of Manual
GCS (Manual)		1263	100%	363	100%
GCCT	Tools	255	20.1%	167	46.0%
	Game	59	4.67%	93	25.6%

		Hrs		LoC	
GCS (Manual)		8.267		363	
GCCT	Domain Analysis	0.617	=5.85	0	=260
	Meta-model	+0.783		+118	
	Data-model	+0.55		+93	
	Editor (and debug)	+0.9		+0	
	Generator	+3		+49 (modified part)	

GCCT: Evaluation



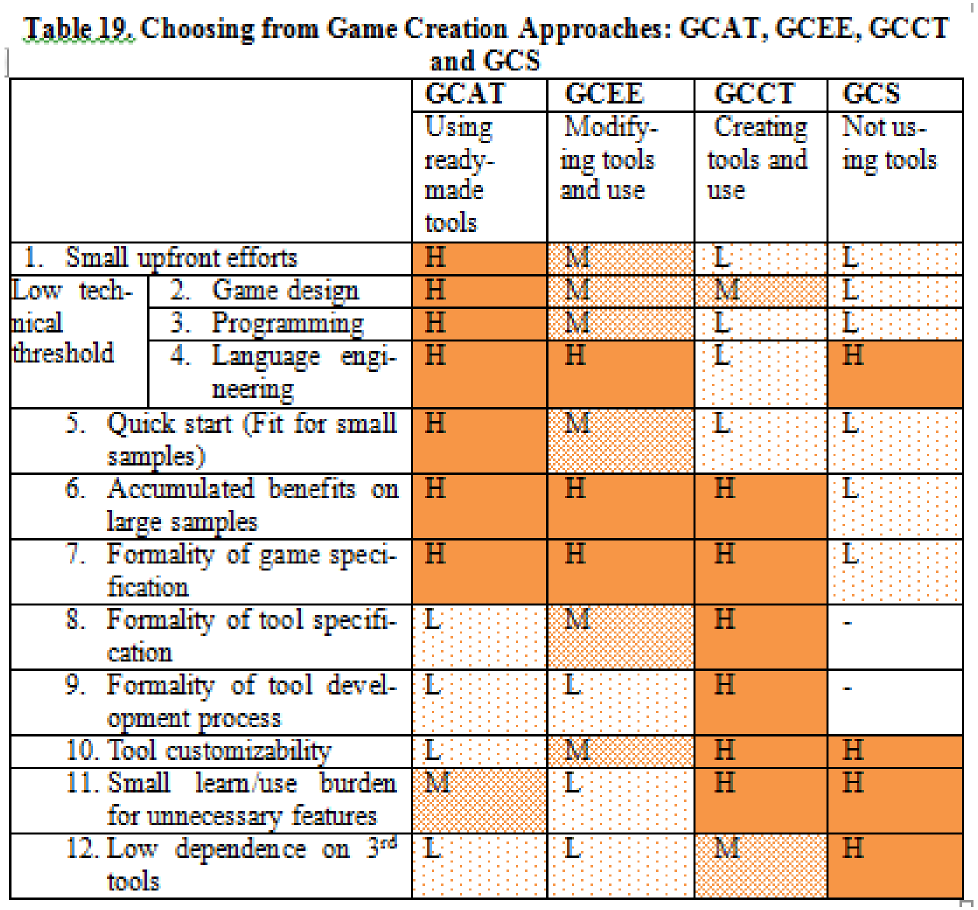
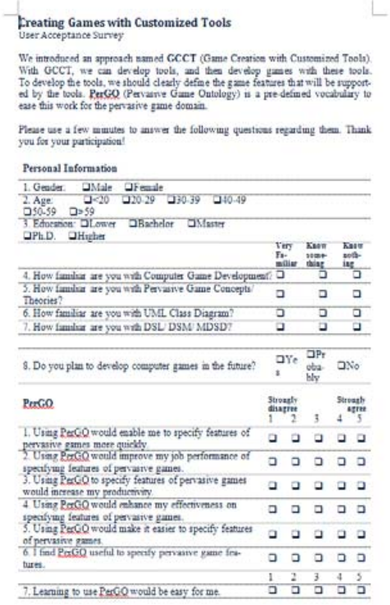


Table 19. Choosing from Game Creation Approaches: GCAT, GCEE, GCCT and GCS

		GCAT Using ready-made tools	GCEE Modifying tools and use	GCCT Creating tools and use	GCS Not using tools
1. Small upfront efforts		H	M	L	L
Low technical threshold	2. Game design	H	M	M	L
	3. Programming	H	M	L	L
	4. Language engineering	H	H	L	H
5. Quick start (Fit for small samples)		H	M	L	L
6. Accumulated benefits on large samples		H	H	H	L
7. Formality of game specification		H	H	H	L
8. Formality of tool specification		L	M	H	-
9. Formality of tool development process		L	L	H	-
10. Tool customizability		L	M	H	H
11. Small learn/use burden for unnecessary features		M	L	H	H
12. Low dependence on 3rd tools		L	L	M	H

GCCT (&PerGO) Evaluation: User Acceptance

- RQ1: Will PerGO and GCCT be accepted by potential users?
  - MDD has drawbacks: cost, technical threshold…
  - Persons are often resistant to use MDD due to such drawbacks
  - GCCT enhanced MDD in game domain
- RQ2: Will game and MDD background hinder the user acceptance of PerGO and GCCT?



Creating Games with Customized Tools
User Acceptance Survey

We introduced an approach named **GCCT** (Game Creation with Customized Tools). With GCCT, we can develop tools, and then develop games with these tools. To develop the tools, we should clearly define the game features that will be supported by the tools. PerGO (Pervasive Game Ontology) is a pre-defined vocabulary to ease this work for the pervasive game domain.

Please use a few minutes to answer the following questions regarding them. Thank you for your participation!

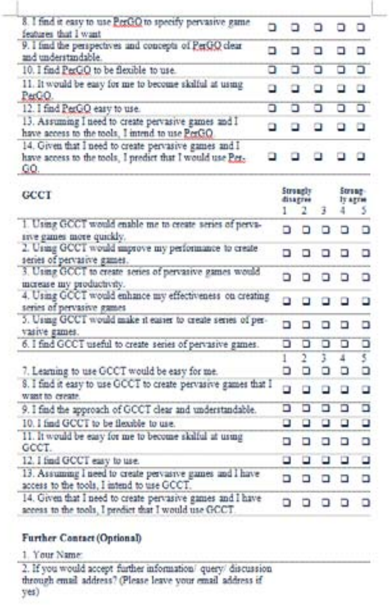
Personal Information

1. Gender: ❑Male ❑Female
2. Age: ❑<20 ❑20-29 ❑30-39 ❑40-49 ❑50-59 ❑>59
3. Education: ❑Lower ❑Bachelor ❑Master ❑Ph.D. ❑Higher

	Very Familiar	Know something	Know nothing
4. How familiar are you with Computer Game Development?	❑	❑	❑
5. How familiar are you with Pervasive Game Concepts/ Theories?	❑	❑	❑
6. How familiar are you with UML Class Diagram?	❑	❑	❑
7. How familiar are you with DSL/ DSM/ MDSD?	❑	❑	❑

8. Do you plan to develop computer games in the future?	❑Yes	❑Probably	❑No

PerGO	Strongly disagree 1	2	3	4	Strongly agree 5
1. Using PerGO would enable me to specify features of pervasive games more quickly.	❑	❑	❑	❑	❑
2. Using PerGO would improve my job performance of specifying features of pervasive games.	❑	❑	❑	❑	❑
3. Using PerGO to specify features of pervasive games would increase my productivity.	❑	❑	❑	❑	❑
4. Using PerGO would enhance my effectiveness on specifying features of pervasive games.	❑	❑	❑	❑	❑
5. Using PerGO would make it easier to specify features of pervasive games.	❑	❑	❑	❑	❑
6. I find PerGO useful to specify pervasive game features.	❑	❑	❑	❑	❑
	1	2	3	4	5
7. Learning to use PerGO would be easy for me.	❑	❑	❑	❑	❑



8. I find it easy to use PerGO to specify pervasive game features that I want	❑	❑	❑	❑	❑
9. I find the perspectives and concepts of PerGO clear and understandable.	❑	❑	❑	❑	❑
10. I find PerGO to be flexible to use.	❑	❑	❑	❑	❑
11. It would be easy for me to become skilful at using PerGO.	❑	❑	❑	❑	❑
12. I find PerGO easy to use.	❑	❑	❑	❑	❑
13. Assuming I need to create pervasive games and I have access to the tools, I intend to use PerGO.	❑	❑	❑	❑	❑
14. Given that I need to create pervasive games and I have access to the tools, I predict that I would use PerGO.	❑	❑	❑	❑	❑

GCCT	Strongly disagree 1	2	3	4	Strongly agree 5
1. Using GCCT would enable me to create series of pervasive games more quickly.	❑	❑	❑	❑	❑
2. Using GCCT would improve my performance to create series of pervasive games.	❑	❑	❑	❑	❑
3. Using GCCT to create series of pervasive games would increase my productivity.	❑	❑	❑	❑	❑
4. Using GCCT would enhance my effectiveness on creating series of pervasive games	❑	❑	❑	❑	❑
5. Using GCCT would make it easier to create series of pervasive games.	❑	❑	❑	❑	❑
6. I find GCCT useful to create series of pervasive games.	❑	❑	❑	❑	❑
	1	2	3	4	5
7. Learning to use GCCT would be easy for me.	❑	❑	❑	❑	❑
8. I find it easy to use GCCT to create pervasive games that I want to create.	❑	❑	❑	❑	❑
9. I find the approach of GCCT clear and understandable.	❑	❑	❑	❑	❑
10. I find GCCT to be flexible to use.	❑	❑	❑	❑	❑
11. It would be easy for me to become skilful at using GCCT.	❑	❑	❑	❑	❑
12. I find GCCT easy to use.	❑	❑	❑	❑	❑
13. Assuming I need to create pervasive games and I have access to the tools, I intend to use GCCT.	❑	❑	❑	❑	❑
14. Given that I need to create pervasive games and I have access to the tools, I predict that I would use GCCT.	❑	❑	❑	❑	❑

Further Contact (Optional)

1. Your Name:

2. If you would accept further information/ query/ discussion through email address? (Please leave your email address if yes)

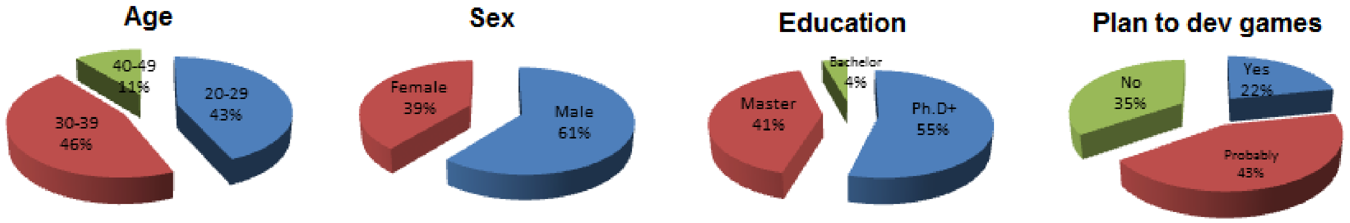


Figure 92. Demographics of the Respondents

❑ 46 responded to the survey

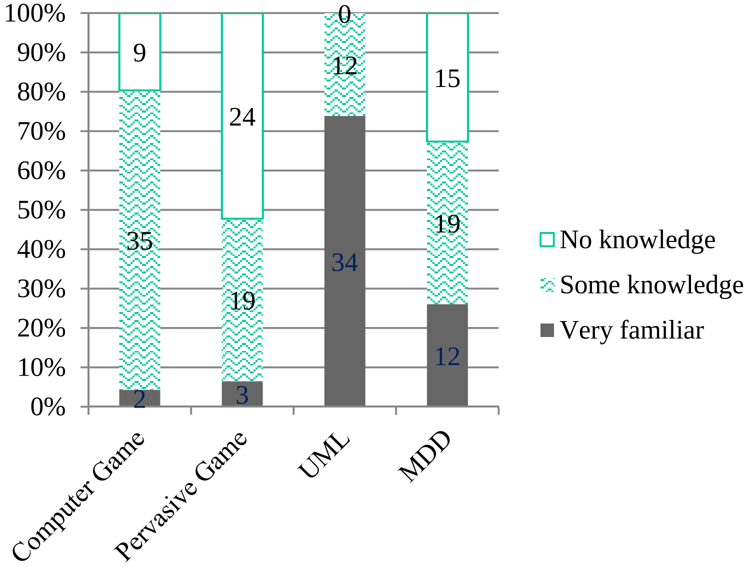


Figure 93. Domain Knowledge of the Respondents

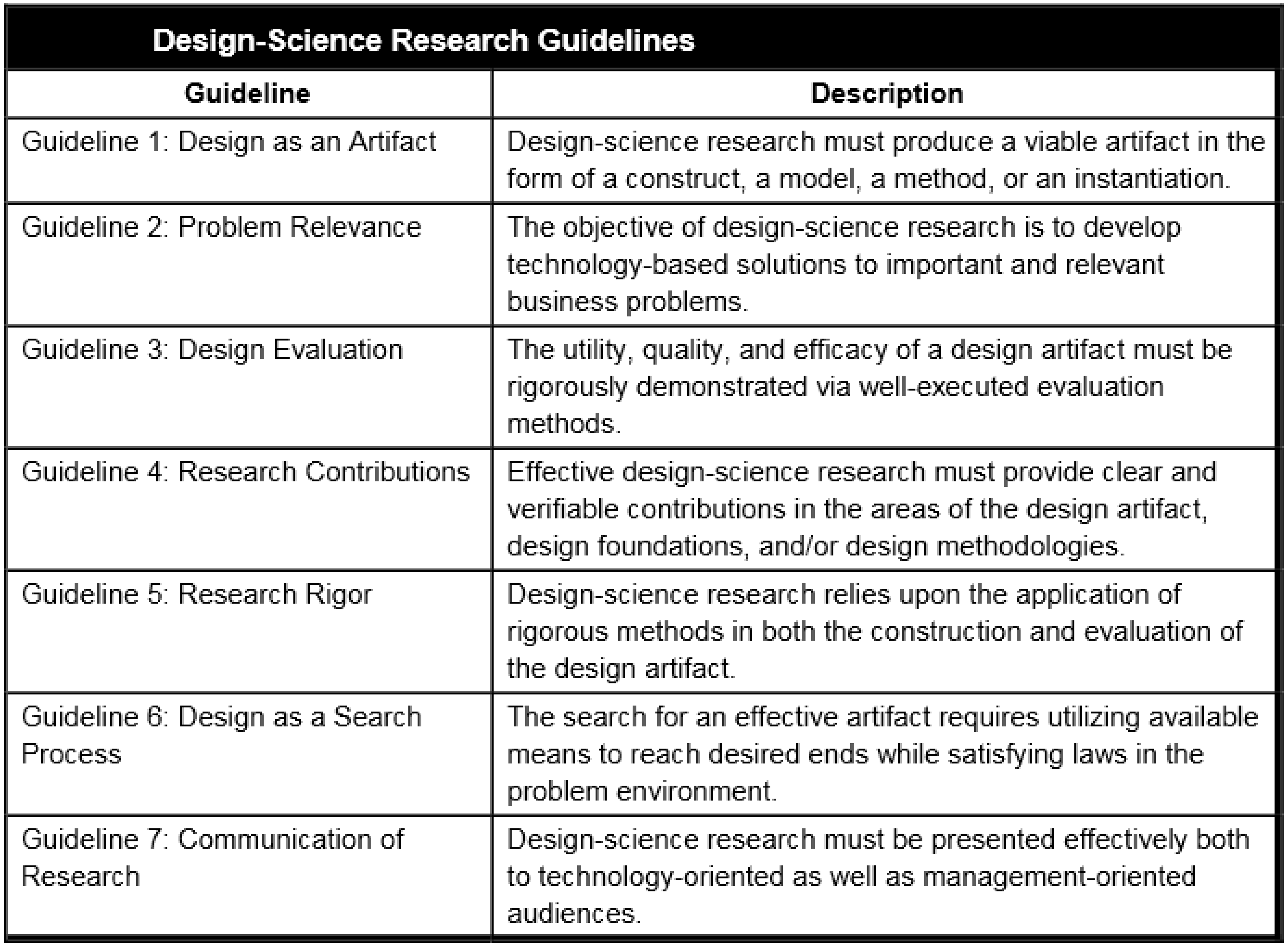
Result:

- Both PerGO and GCCT were perceived to be useful, easy to use, and might be adopted by most of the respondents.
- People with some pervasive game knowledge might find PerGO to be more useful and more easy to use.
- Knowledge of general computer game development and MDD expertise did not obviously influence the usefulness and the ease of use of PerGO or GCCT.

Agenda

- Introduction
  - Problem Statement
  - Research Questions and Challenges
  - Research Contributions
  - Research method
- RC1: TeMPS
  - Introduction
  - State of art
  - Evaluation
- RC2: PerGO
  - Introduction
  - State of art
  - Evaluation
- RC3: GCCT
  - Introduction
  - State of art
  - Evaluation
- Conclusion and Future work
  - Research Method
  - TeMPS
  - PerGO
  - GCCT

Evaluation:
Research Method



Design-Science Research Guidelines	
Guideline	**Description**
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Limitation and Future Work: TeMPS

- The four dimensions defined in TeMPS are quite uneven.
- The suggested set of perspectives or their options/aspects is not exhaustive
- TeMPS does not specify which features are mandatory or optional for a pervasive game.
- TeMPS is somewhat empirical and lacks solid theoretical ground.
- The scoring criteria based on TeMPS can be made less subjective.

Limitation and Future Work: PerGO

- PerGO will be extended
  - more perspectives such as sociality, network communication, architecture, etc.
- PerGO will be refined and evolved
  - the concepts can be refined and evolved by carrying out more case studies.

Limitation and Future Work: GCCT

- GCCT will be extended
  - More aspects of game creation may be explored
    - management,
    - document transitions, and
    - participants' cooperation
- GCCT will be further evaluated and refined
  - The ultimate goal is to improve the overall process of model driven game development
  - The *practical environment and tools* to support the usage of PerGO and GCCT should be constructed and enhanced.
  - *Benchmark game applications* need to be developed.
  - *Larger scale user experiments* and surveys can be performed to allow external participants to try out the approach and provide comments.
  - More participants from the game industry might be recruited.

- Thanks!