Article

Coding as Literacy at Preschool: A Case Study

Supplementary material

Table S 1 - Learning methodologies per approach to computation and content area

Approach to computation / Content area	Expression and Communication	Knowledge of the World	Multidisciplinary
Computational thinking (with ICT)	-	field trip / itinerary representation	storytelling with cubes recipe planning/execution
Unplugged computational thinking	game/challenges (floor activities, role-play embodiment, board, worksheet pixel-art); drawing/representation; itinerary representation; recipe; role-play/embodiment (child as a robot); sequencing/pattern (visual, 3d art, worksheet); storytelling/visual storytelling; algorithm worksheets	recipe concept map / diagram storytelling	nursery rhymes/singing storytelling, drawing/representation free play
Coding	random sequence building (ScratchJr)	ScratchJr self-directed exploration	storytelling with ScratchJr thematic project (Christmas card)
Robotics	thematic coding challenges self-directed exploration storytelling	coding challenges self-directed exploration	self-directed exploration coding challenges (storytelling, floor game, thematic, no theme)
Multiple approaches	role-play/embodiment (child-robot)	-	itinerary planning/ representation storytelling with ScratchJr (visual) storytelling tangible pattern building (3d objects)

Table S 2 - Curricular content per approach to computation and content area

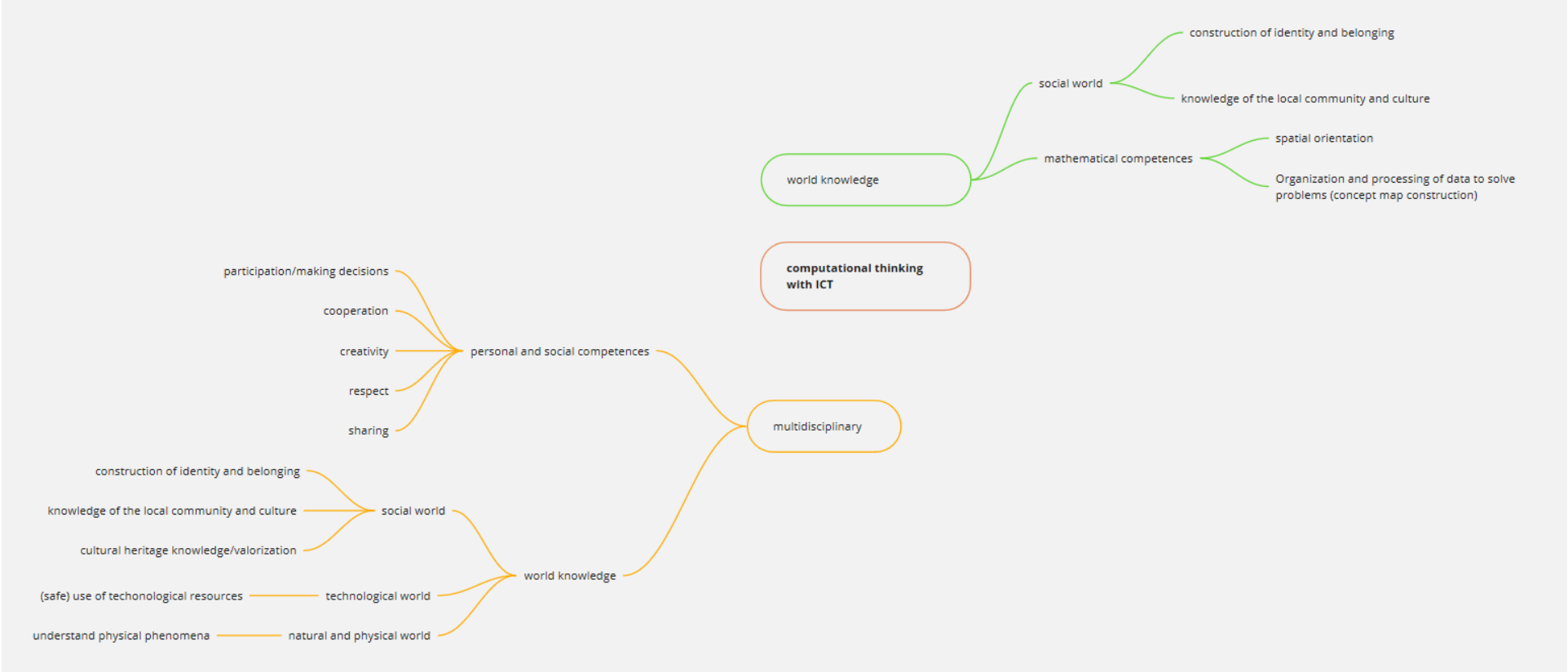
Approach to computation / Content area	Expression and Communication	Knowledge of the World	Multidisciplinary
Computational thinking (with ICT)	-	Local natural and social environment	Democracy and citizenship identity and self-esteem Feeling capable and enjoying learning oral language and written approach geometric shapes information selection visual language paper cutting ICT
Unplugged computational thinking	approaches to writing approaches to reading oral language algorithm orientation concepts conceptual map numbers notions of space/direction patterns routes spatial reasoning geometric figures graphic register body awareness/body control manual dexterity fine motor skills cutting and pasting colors curiosity and interest days of the week	festivities autumn fruits traffic rules	home/family transportation festivities (three kings day) oral language visual language patterns feeling able and enjoying learning
Coding	Oral language	ScratchJr	approach to writing oral language ability and pleasure for learning citizenship identity and self-esteem independence and autonomy feeling capable and enjoying learning natural scenes associated with christmas Christmas living beings digital drawing numbers dramatic acting

			ScratchJr animation of a narrative digital drawing tablet digital postcard QR code safe use of technologies
Robotics	oral language narrative approaches to writing letters animals colors drawing geometric shapes geometry measurement numbers and operations data organization and processing orientation and spatial visualization programming	educational robot (tangible programming) educational robot (directional programming)	approaches to writing approach to reading oral language democracy and citizenship identity and self-esteem independence and autonomy visual communication elements visual language family social belonging world places and cultures geometric shapes geometry measurement numbers and operations robot programming feeling capable and enjoying learning
Multiple approaches	-	-	nutrition body outer space oral language visual language drawing directions, paths patterns participation in Code week Scratchjr interactive whiteboard feeling capable and enjoying learning

Learning goals per approach to computation and content area

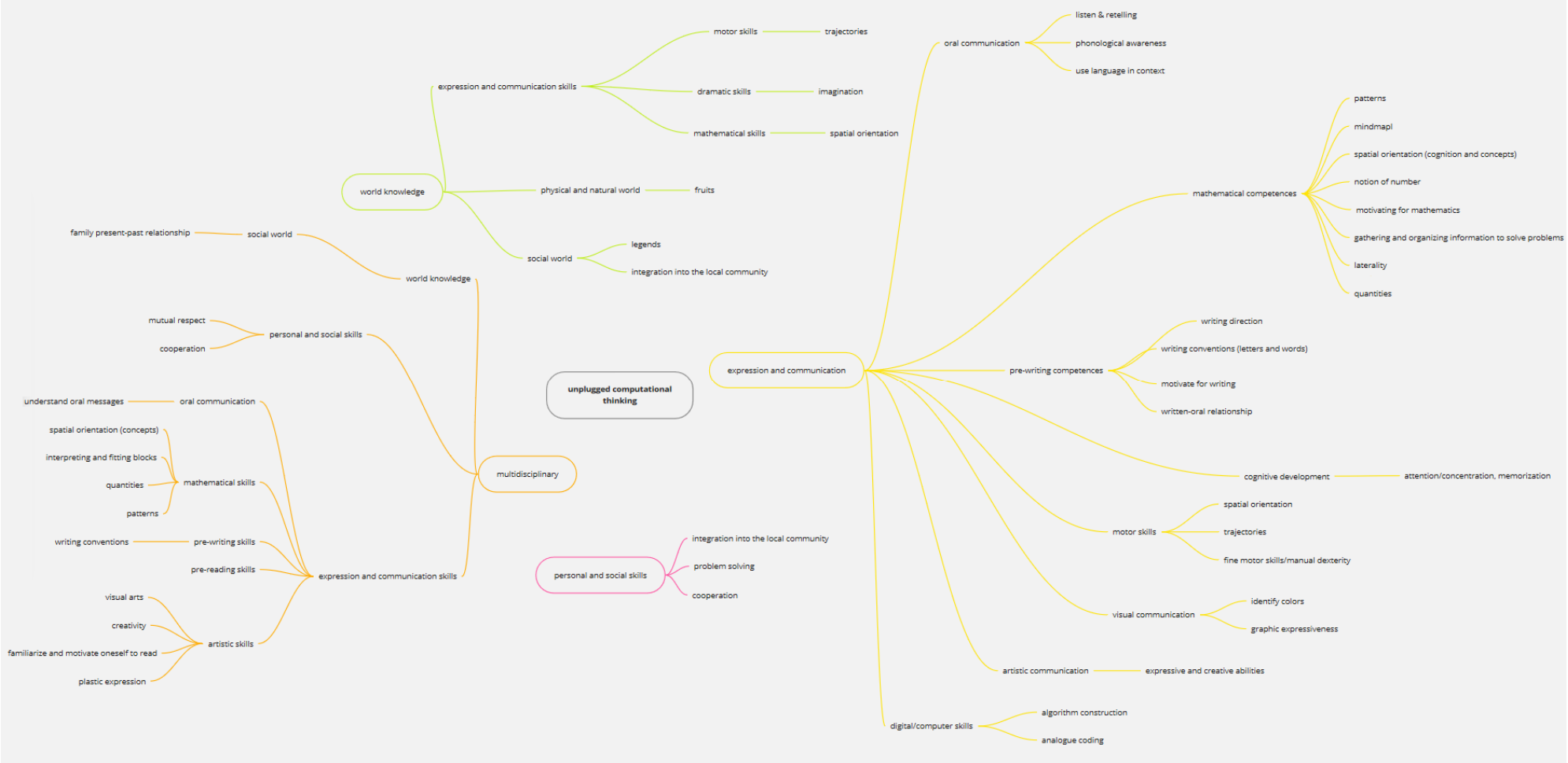
Regarding computational thinking activities with commonly used ICT, learning goals split in two branches: 'world knowledge' and 'multidisciplinary' purposes (figure S1). 'World knowledge' wise, our analysis rather points to 'multidisciplinary' goals, with social world competencies, such as achieving a sense of belonging and knowledge of local culture, pursued together with mathematical competencies, notably spatial awareness and organizing information through conceptual maps. Regarding 'multidisciplinary' purposes, 'personal and social' competences, such as respect, cooperation and participation, go hand in hand with broad 'world knowledge' themes, concerning natural, social and technological aspects.

Figure S 1 - Learning goals: Computational thinking with ICT



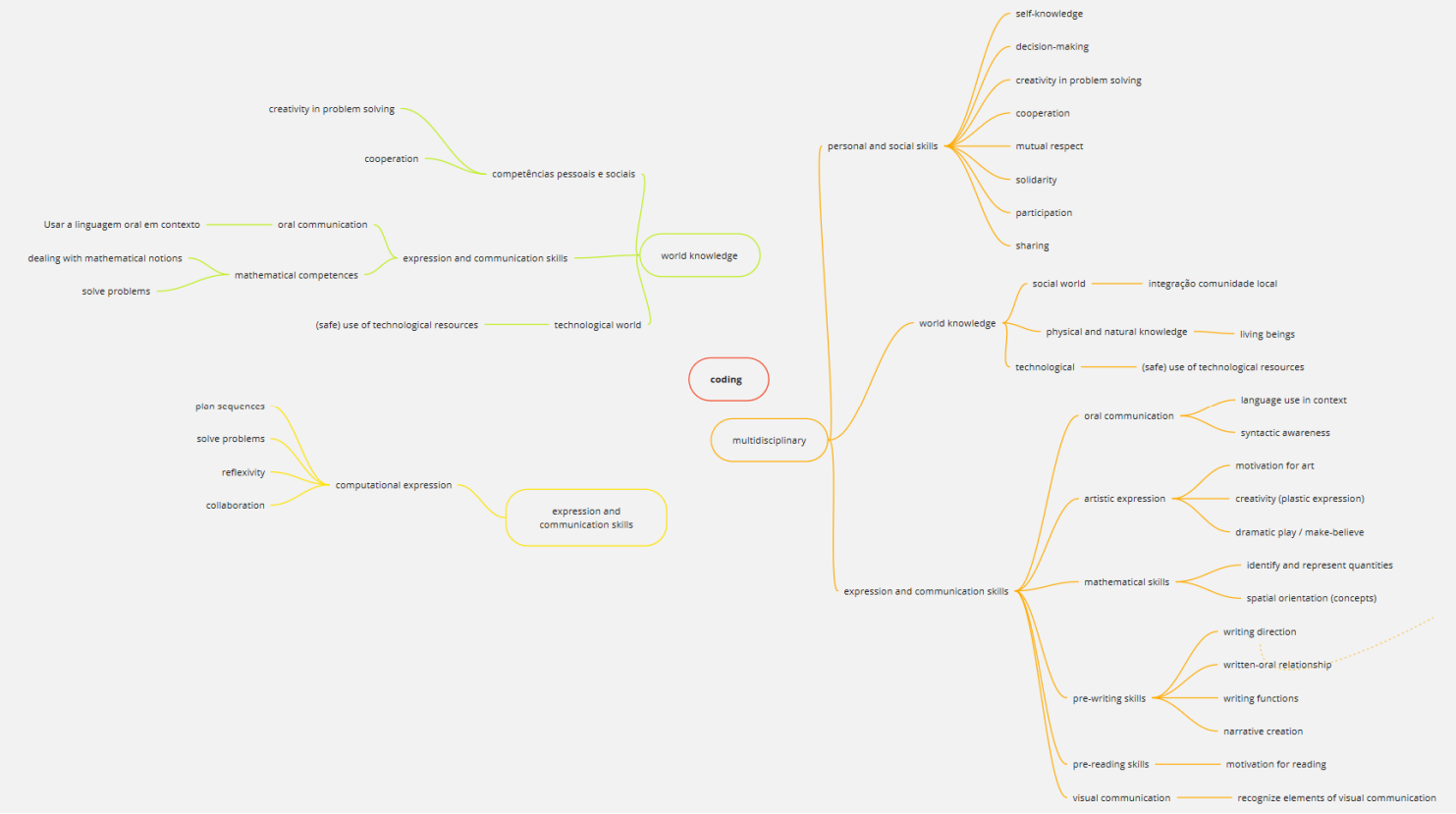
Unplugged computation activities offer a more complex map of objectives, encompassing all three main areas at pre-school's curricular matrix (figure S2). Together with the work developed within combined multiple approaches to computation, unplugged approaches directly mention pursuing 'personal and social' competencies objectives, such as sense of belonging, problem-solving and cooperation. With respect to 'world knowledge', our inductive analysis pointed to three branches: social world; natural and physical world; 'expression and communication' competencies.

Figure S 2 - Learning goals: Unplugged computational thinking



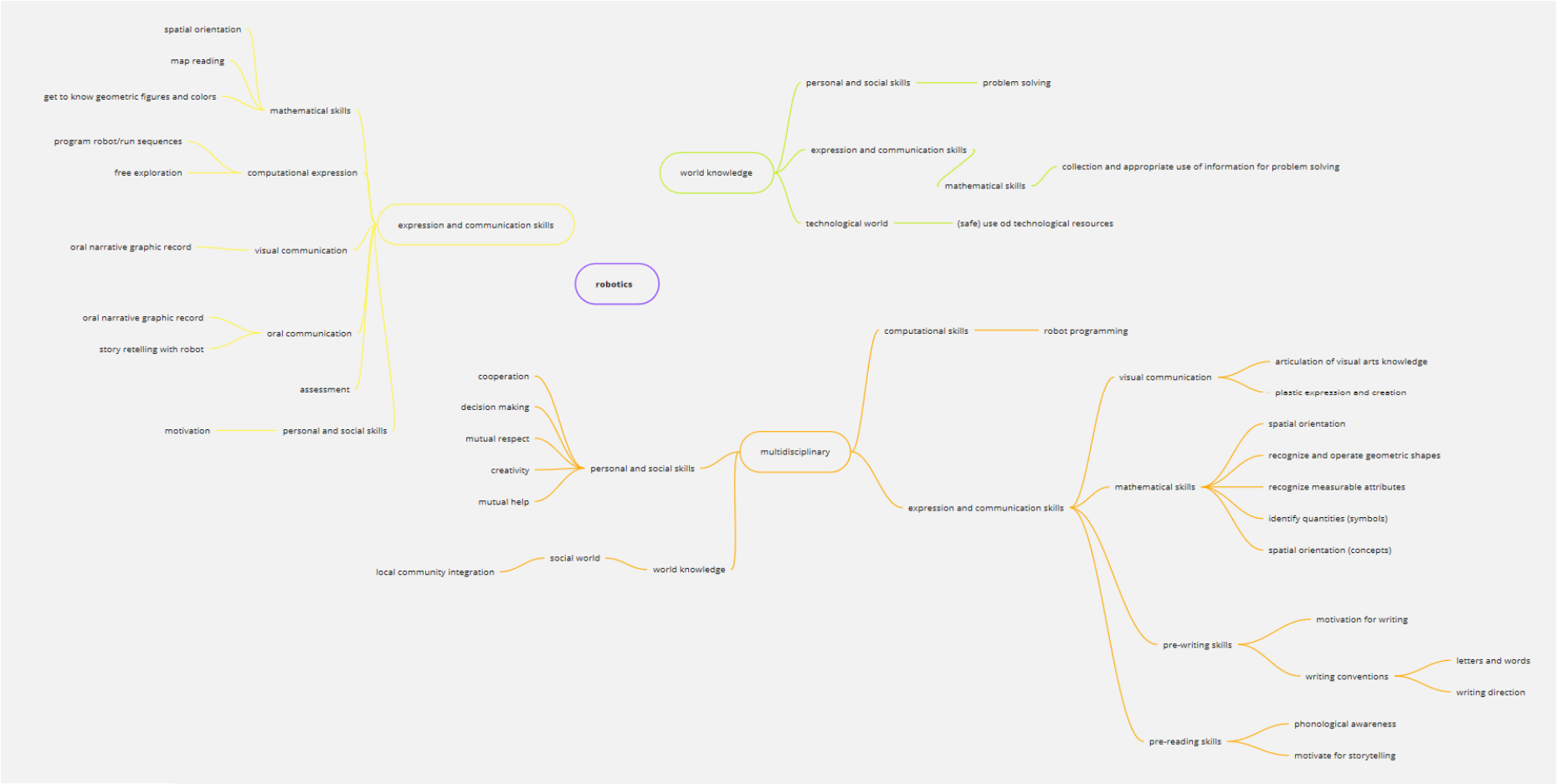
Resorting exclusively to ScratchJr as a coding environment, hence its prone storytelling design, objectives within this approach to computation emerged in close connection with storytelling related competences (figure S3). Educators' goals were set within 'world knowledge', 'expression and communication' and 'multidisciplinary' areas. Inductive analysis of 'world knowledge' activities branched into three themes: 'personal and social' competences; 'expression and communication'; 'technological world'. These approached, respectively: Development of cooperation and problem-solving competences; oral language (use in context) and mathematical notions; safe use of technology. 'Expression and communication' encompassed what could be considered computational expression and/or computational thinking, notably: sequence planning, problem solving, reflection, cooperation. 'Multidisciplinary' wise, the picture becomes more complex. Three themes emerge: objectives within 'personal and social' competences (self-knowledge, decision making, problem-solving, etc.), 'world knowledge' (social, natural and technological, respectively local community belonging, living beings, safe use of technology) and 'expression and communication'(oral, artistic, mathematical, etc.) (figure S3).

Figure S 3 - Learning goals: Coding



Robotics' mindmap presents a similarly complex and 'multidisciplinary' prone picture (figure S4). Educators distinguished three main knowledge areas: 'expression and communication', 'world knowledge' and 'multidisciplinary'. Our inductive analysis lenses rather points to an overall 'multidisciplinary' chart. 'expression and communication' competences surface across all branches, as well as 'personal and social' skills. Nonetheless, skills in the scope of 'expression and communication' stand out, in several domains: mathematical, visual, oral and pre-reading and writing. Computational related objectives appear in connection to 'expression and communication', but not exclusively. These are: programming and executing sequences; free exploration.

Figure S 4 - Learning goals: Robotics



Concerning multiple approaches (figure S5), notably combining moments of unplugged and plugged activities, 'expression and communication' objectives largely prevailed as educators' main targets. Besides a few remarks to knowledge about the technological world, cooperation and integration with other digital competences related projects, oral, visual, mathematical and computational competences emerged as sub-themes. In this case, as we will further discuss, computation falls under an 'expression and communication' category rather than a technological one. This aims to reflect how educators used computation as a means for children to express themselves rather than to directly develop technological skills in itself.

Figure S 5 - Learning goals: multiple approaches

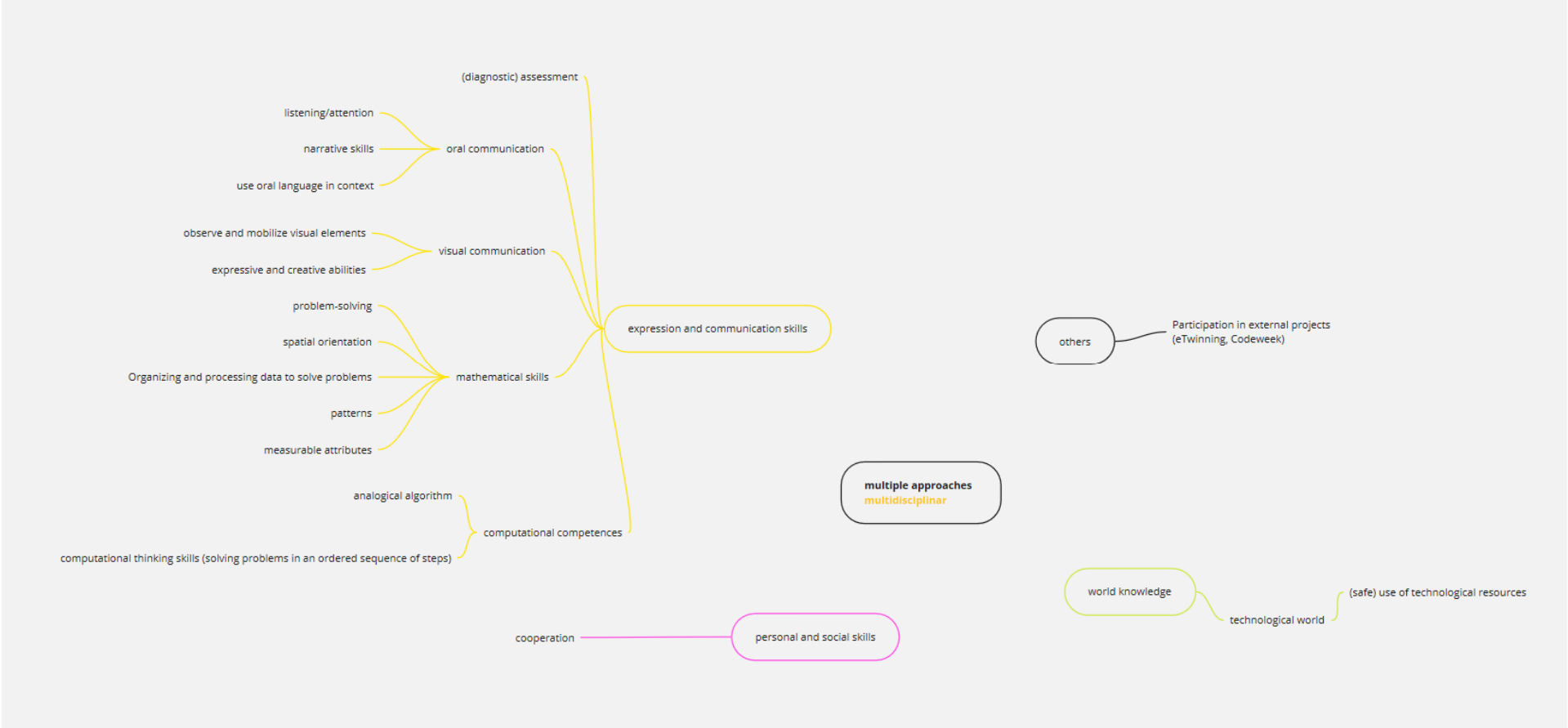


Figure S 6 - Children's reactions

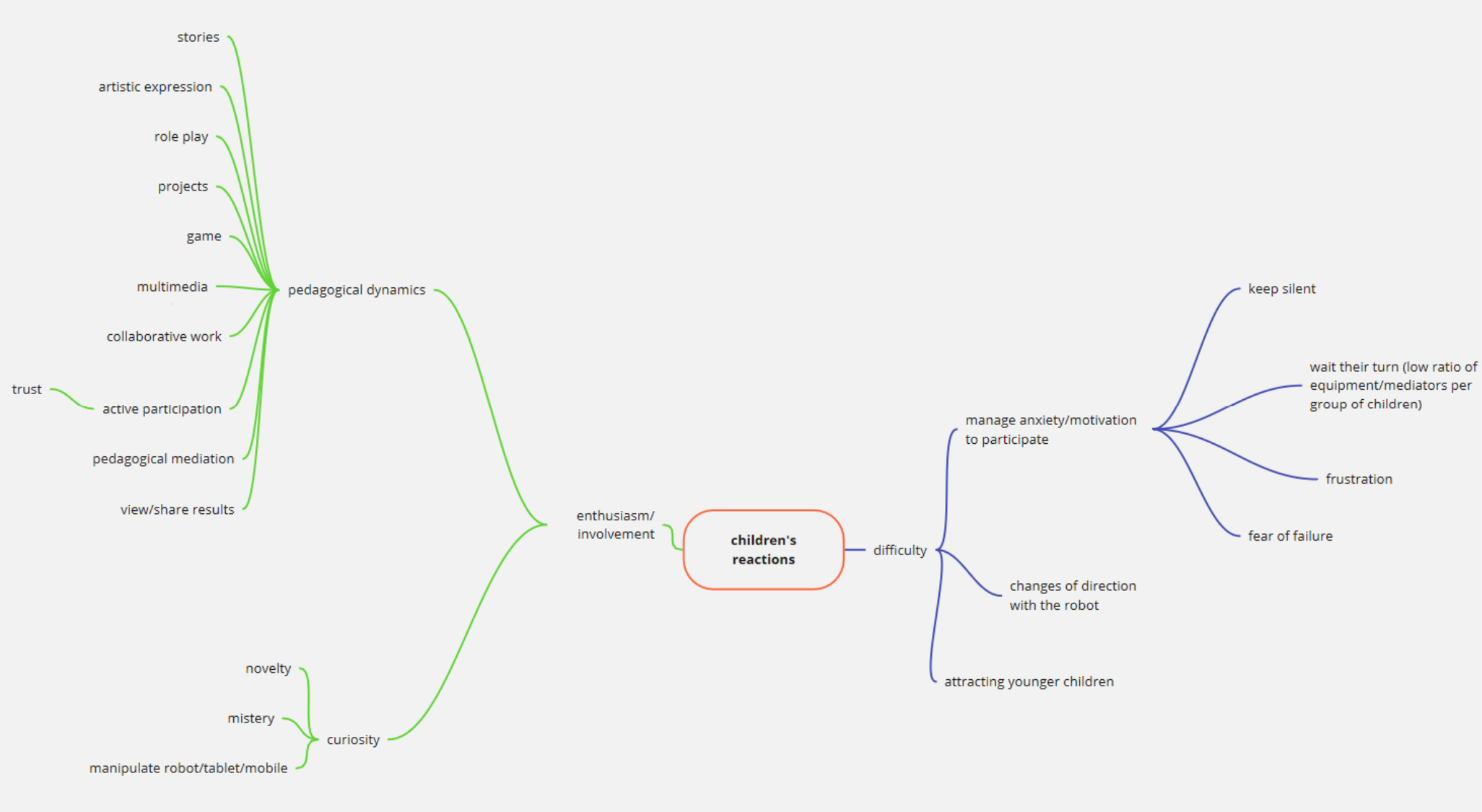


Figure S 7 - Positive aspects: Computational thinking with ICT

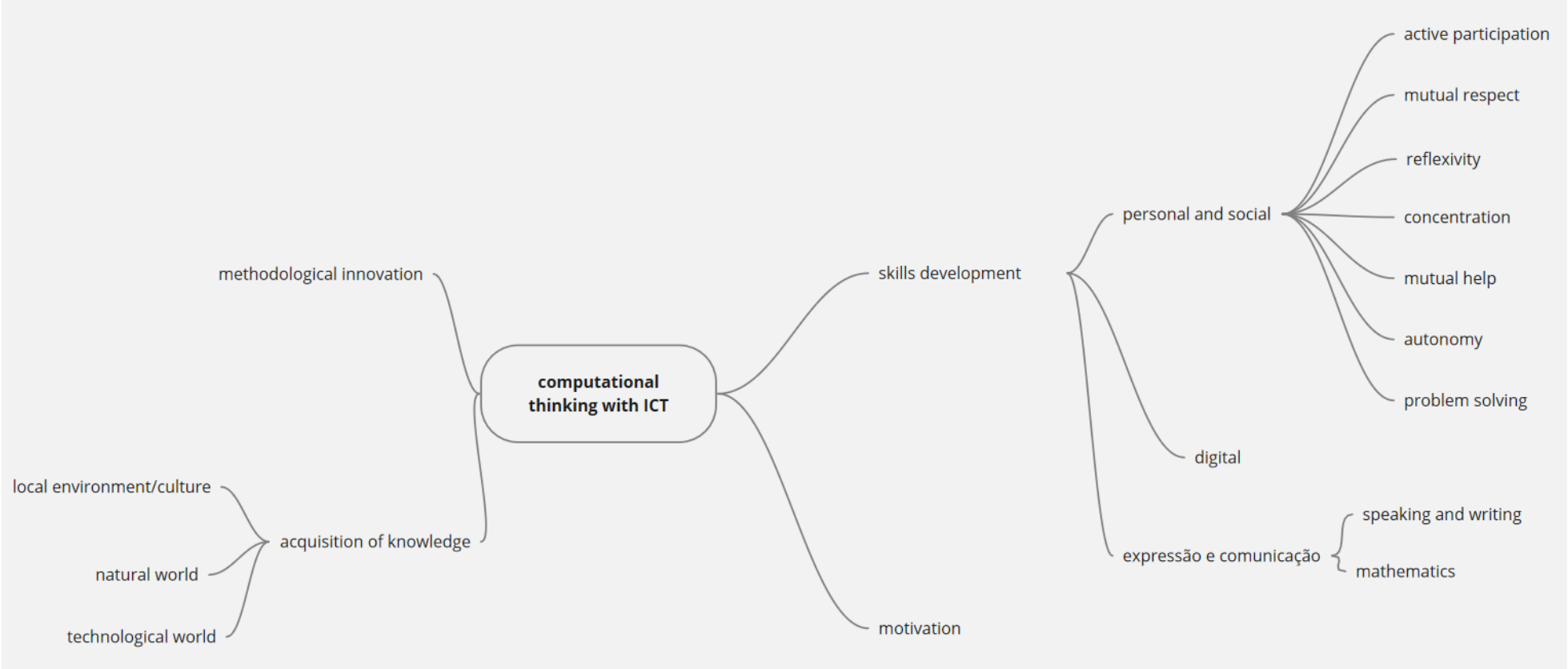


Figure S 8 - Positive aspects: Unplugged computational thinking

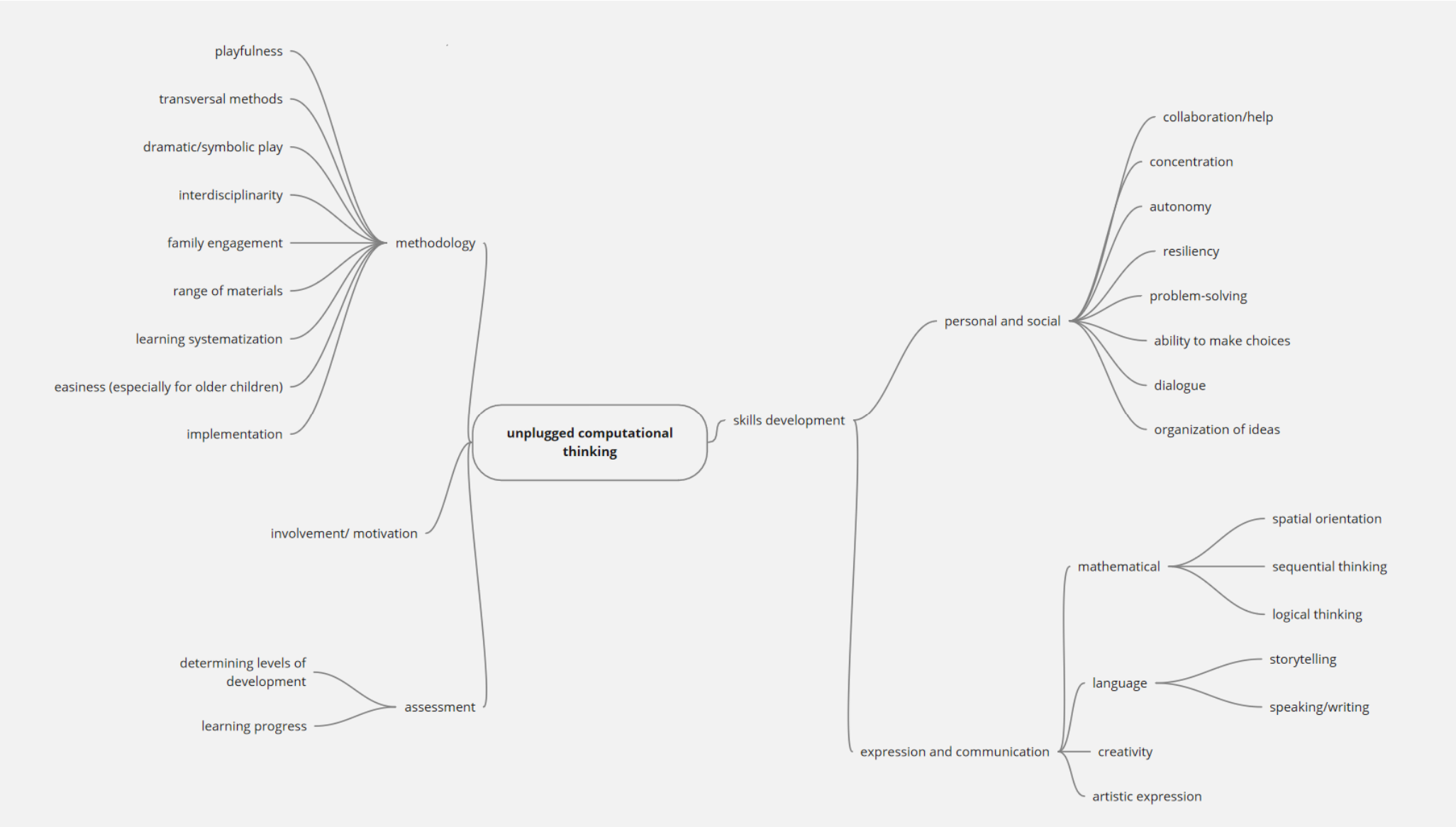


Figure S 9 - Positive aspects: Coding

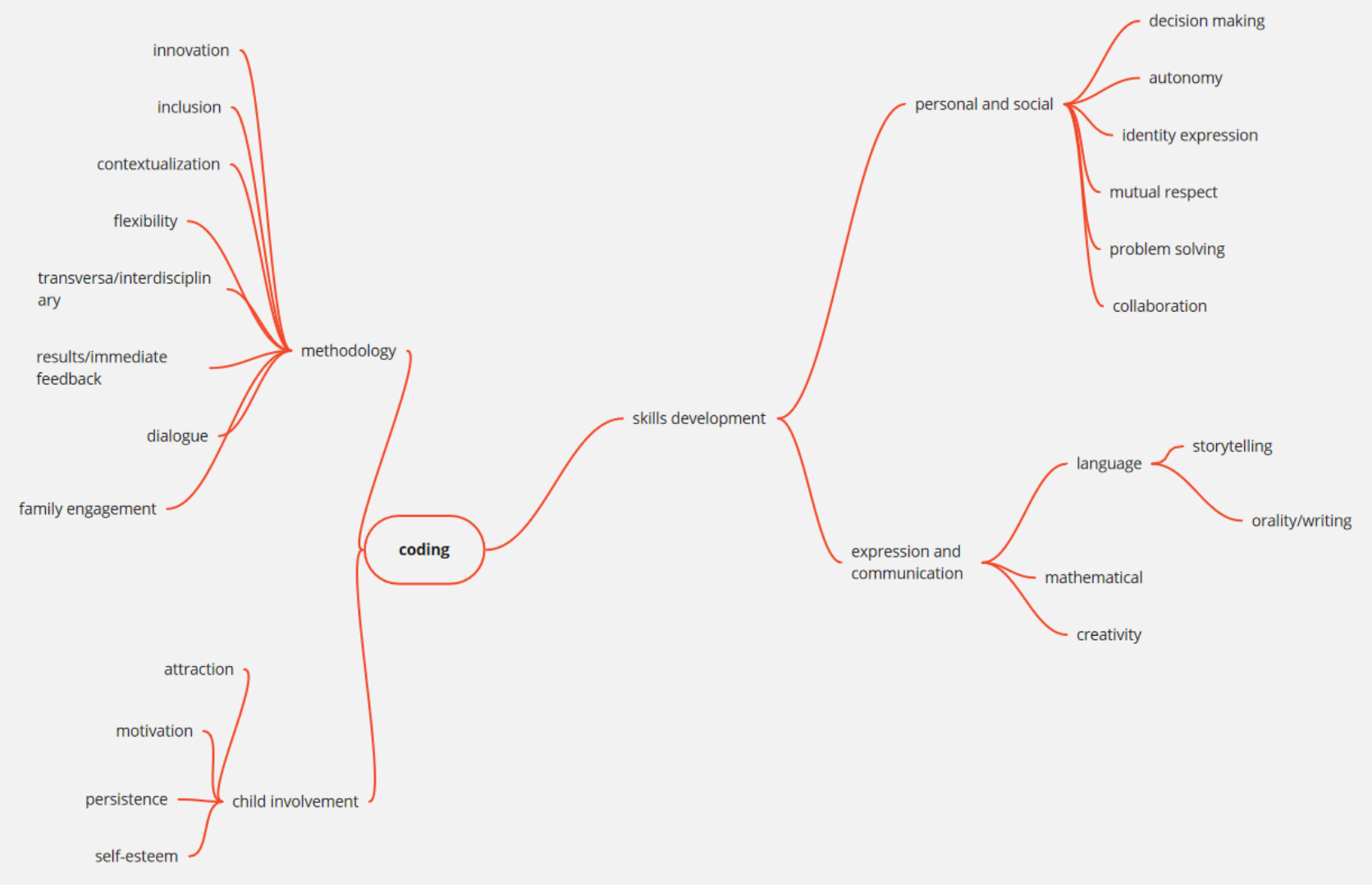


Figure S 10 - Positive aspects: Robotics

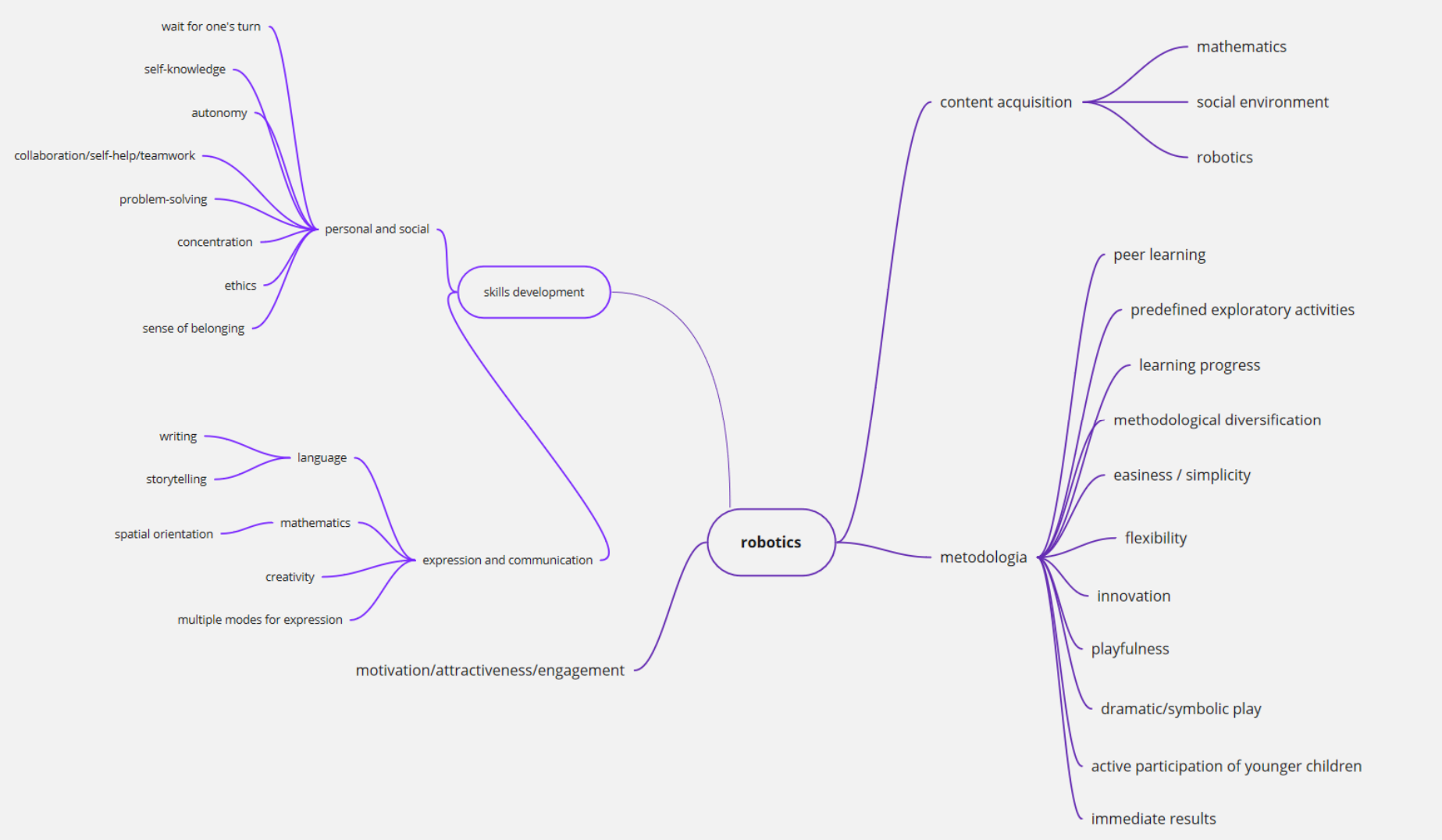


Figure S 11 - Positive aspects: Multiple approaches

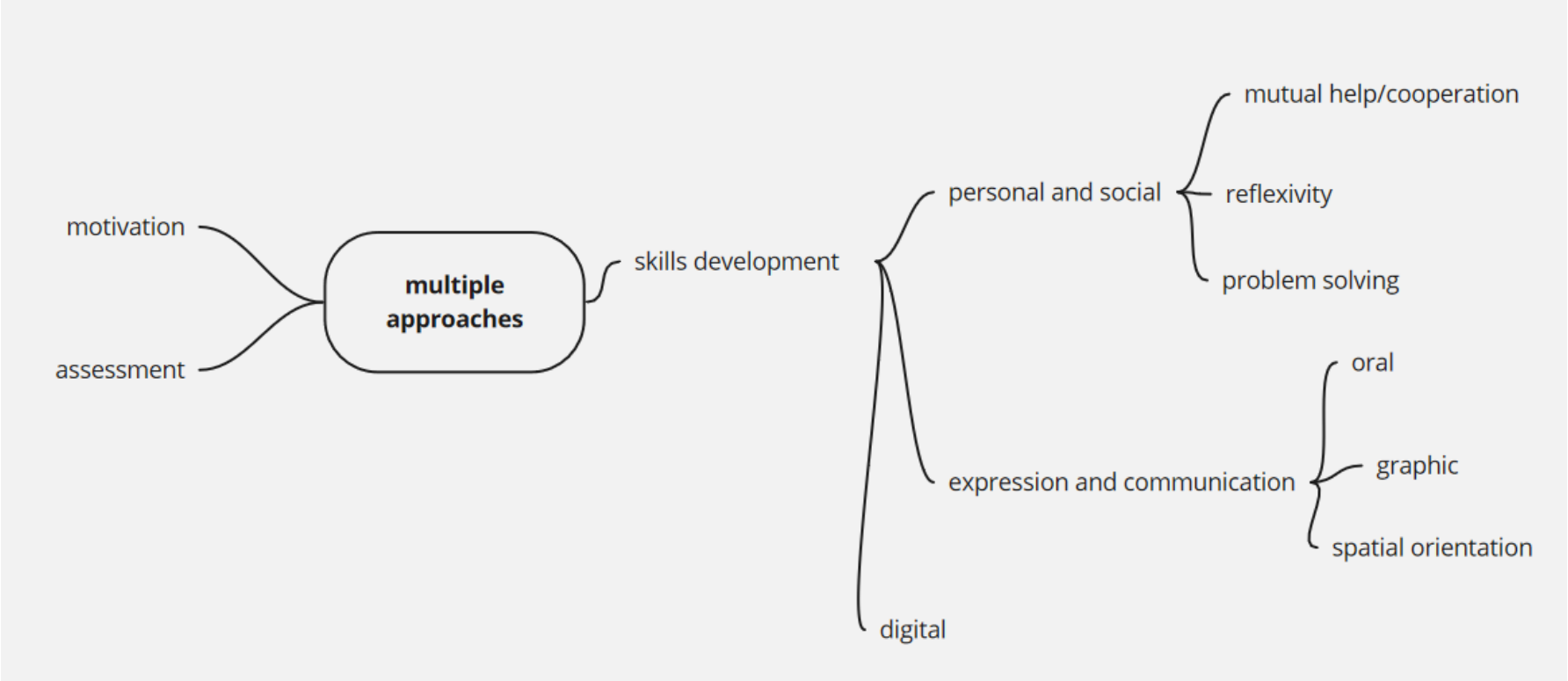


Figure S 12 - Negative aspects