Tasks for Mediating the Process of Knowing and Learning to Design and Make

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Research in Design and Technology Education (D&TE) suggests that teachers need to appreciate the critical aspects of design and make. These aspects include developing an understanding of ill-structured problems, role of imagery and visualisation, need for collaboration and the influence of values in design thinking. The study reported in this paper explored the use of carefully designed tasks to develop critical reflection on the design and make processes among student-teachers (participants). The participants were 34 masters' students who opted for D&TE course as part of their teacher preparation programme taught by the teacher-researcher (author). An analysis of participants' engagement with two of the tasks designed by the author revealed challenges in attending to functional and structural details of artefacts, particularly when making shifts between micro and macro features. The tasks mediated the process of knowing and learning how to design and make, by affording simultaneous attention to cognitive, metacognitive and affective experiences in classroom discussions. As participants worked on tasks, the interplay of knowledge and skills created opportunities for discussing epistemic identity. The study suggests that learning mediated through design-and-make engagements provides an inward gaze into the process of designing and the purposes of technology. The paper concludes with the affordance of contextual and experientially informed understanding in handling the challenges of preparing teachers to teach design-and-make.

Keywords: authentic learning, design consciousness, epistemic identity, tasks, teaching-learning

The formative nature of teaching-learning

Teaching is a complex activity (Calderhead, 1994). Besides the curricular content, pedagogy and assessments, teachers consciously address the influences from socio-economic, cultural and linguistic backgrounds of learners. Teacher's agency in negotiating the complex interplay of influences make learning possible. The processes of teaching-learning are contextual, situated and involve an iterative, discursive engagement with learners and their ideas (Koschmann, 2011; Pritchard, 2009). A reflexive engagement with ongoing teaching discourse can optimise the learning gains. In such a situation, teaching-learning activity attains a formative character that emerges and co-evolves through the process of learner engagement.

In many ways, a teacher experiments with her/his pedagogy, gauging insights into how ideas translate to practice and simultaneously handling some of the vexed issues arising from a synthesis of research about and through classroom practice. In the absence of exemplars for Design and Technology Education (D&TE) engagements in the Indian context, the pedagogic experiments may well become the source and means for meaningful translation of ideas into curricular practice (Khunyakari, 2020). The practice resting on this belief would enable realise 'deliberative curriculum', which dynamically responds to the contextual needs, knowledge, skills and cultural exposure, and the larger goals within which pedagogic experiments happen.

From contexts of immersion to contexts of relevance

Technological design problem solving is essentially contextual. Creating learning experiences which are contextually meaningful is challenging for a teacher. In search of a non-alienating and appropriate

context, we tend to rely on the immediate environment around us. Although this may be a promising place to begin with, enacting and sustaining such a context is complex in practice. Antweiler (1998) discusses the instrumental role of local knowledge in learning and cautions us to an oversimplified or overenthusiastic treatment of contexts which in turn compromise conceptual understanding. In the context of pedagogic judgement, it is important to rationalise how tasks involving artefacts and embodying local knowledge, selected from our immediate milieu of encounters, can reliably be converted into contexts of inquiry with meaning, purpose and direction. An engagement guided by this understanding of contextual relevance may help us not fall prey to trivialities or conceptual truisms. Arguing for the salience of context in situating design and make experiences, Kimbell, Stables & Green (1996, p11) argued,

> Real tasks do not exist *in vacuo*. They exist in real houses or gardens or shops or car parks or hospitals and the *setting* of the task is a major determinant of the *meaning* of that task…In each case the issues that the designer needs to consider are to a large degree defined by the *context*. Equally, the success of the outcome can only be determined by examining its operation in the same context.

Evidently, contextualising allows us to build relevance and develop the character of learning intended and embodied in the various activities within a task. Further, a carefully organised task sequence may optimise critical teaching-learning.

Centrality of 'task' for authentic and meaningful learning

Task-based learning has been used for enabling learning in the domains of language (Pica, 2005; Willis, 2006), mathematics (Zaslavsky & Sullivan, 2011; Sullivan, Clarke & Clarke, 2013) and science (Hewson, 2004) education. More recently, cognitive task design is used in building safe and effective human-technology systems (Hollnagel, 2003). Although inconsistency prevails in capturing the concept of 'task', a growing interest in characterising tasks for pedagogic purposes from across disciplinary domains presents rich and fruitful imaginations. Over the past few years, reports of exemplar cases of engaging individuals in design and make activities have strengthened our understanding about practice. There, however, seems to be little discussion about examining the role of tasks in enriching conceptual foundations about 'design' and 'technology'. Often, philosophy of technology is believed to shoulder the responsibility of building and discussing these conceptual perspectives. However, Pintrich (2002) argues for the salience of explicit teaching of metacognitive knowledge. He asserts that the 'knowledge of tasks and their contexts represents knowledge about different types of cognitive tasks as well as classroom and cultural norms' (p. 225). The value of tasks for 'knowing' and 'learning' about design and technology calls for careful studies and is the focus of this paper.

In the paper, I exemplify that learning mediated through design-and-make engagements provides an inward gaze into the process of designing and on purposes of technology. While engaging student teachers in the reported D&TE tasks, discussions on ill-structured problems, role of imagery and visualisation, value-influenced thinking, etc. emerged, and handling these complexities is challenging in practice. Through carefully designed 'tasks', attention was drawn to the process of design engagement including, processes of designing, inquiring, reflecting and contextualised thinking. Systematic engagement in tasks also contributed to building epistemological foundations of D&TE.

Building an epistemic identity in D&TE

Discourses on how design & technology could be integrated within curricular fold include competing and conflicting perspectives. The perspective on design is a case in point. Ulrich (2005) considers design as a cognitive human phenomenon, governed by a set of principles and practices which need to be understood in order to serve effectively as a designer. Archer (in Roberts, Archer & Baynes, 1992), on the other hand, argues that design is a fundamental human capacity that involves 'cognitive modelling'. Such epistemological tensions come into play and get negotiated in practice. It, therefore, seems

significant to be conscious of not just the purpose and character of an activity but also be alert to the epistemic identities that get carved and negotiated through the processes of active engagement. By extension, this seems to hold true for the processes of learning about design and technology as much as engaging in acts of designing and making. The emergent character of D&TE (Natarajan, 2011) requires that epistemological tensions get discussed and negotiated through a contextualised discourse in the teaching-learning situations. Osbeck and Nersessian (2017, p254) proposed the use of epistemic identities as 'a descriptive tool for understanding collaborative and cognitive practices in interdisciplinary spaces.' They argue that self-representations simultaneously implicate representations of one's collaborators, and thus have implications, and even consequences for the cooperative practices that lead to the production of knowledge. Further, they anticipate that an awareness of and opportunities for developing flexible epistemic identities may facilitate adaptive experience, collaborative potential and expand range of problem-solving possibilities and perspectives. Such an imagination renders it possible to investigate how design and technology endeavours may afford for seamless relation between the otherwise perceived independent cultures of the sciences, humanities and design (Cross, 2006).

Establishing symbiotic relations between knowledge, skills and values

D&TE activities are about enactments of real-life practice as they recreate experiences of real-life design and make. An attention to the formative character of teaching-learning – involving decision making in light of complex influences, governed by efforts towards contextualising learning – can enable and enrich epistemic identity of individuals participating in learning. Investigating into experiencing design and make can reveal epistemic identities-in-play and help prospective teachers or teacher educators develop a certain consciousness. The selection of content needs to allow individuals to reflect on its nature and processes. This is particularly significant with multi- or transdisciplinary domains, which connect to concepts from a range of disciplines. For instance, it is established that design involves ill-structured problems, which both in conceptualisation and solving, are shaped by socio-cultural influences and exposure. A credible imagination of unique nature of design problems requires not just search for kinds and counter-examples but also opportunities for experiencing it. A comparison of design ideas across different groups with guided discussions has the potentials to draw upon existing 'knowing' and develop appreciation for emergent, flexible epistemic identities. Basing the understanding of 'design' and 'technology' through design and make invites participants to explore, tweak and draw upon symbiotic relations between knowledge, skills and values from across disciplines.

Study objectives

This paper reports a part of an ongoing study on the development and use of tasks to engage student teachers in a reflective inquiry on design-and-make processes within D&TE. The investigation aims to capture some such possibilities through the following objectives:

- To analyse tasks and their critical relevance for teaching and engaging participants in thinking about design and technology education (D&TE) issues.
- To understand the nature of responses to specific tasks so as to create evidence-based insights into processes and practice of teaching-learning of D&TE.
- To unpack the evidence-based insights to reflect on the pedagogic possibilities that emerge from such an engagement.

Methodology

The study reported here is part of a larger, ongoing investigation which attempts to integrate teaching, research and development. The study can broadly be located within the methodological framework of design-based research, which strives to achieve a co-ordinated and iterative exchange between needs and objectives of a study along with insights from practice (Bauer-Marschallinger, 2019) in order to

critically inform the practice and the outcomes (Barab & Squire, 2004). The discourse on evidence-based practice (Thomas & Pring, 2004), is a useful approach for analysing the dynamic aspects of learning during the ongoing process of engagement.

Participants in the study

The participants in the study were 34 student teachers (henceforth, participants), pursuing a two years Masters of Arts in Education from an established university. This is the only teacher education programme in India which offers D&TE as an elective course to prospective teachers and teacher educators. The author, a teacher-researcher, has been offering the course for seven years now. The data reported in this paper comes from the teaching in the academic sessions of 2017-18 and 2019-20. The participants represented an eclectic mix of individuals with different educational exposures in terms of their domains of prior study at the undergraduate level (for example, computers, elementary education, english, history, management, media studies, physics, language, cultural histories, etc.). All participants had little or no exposure to developing teaching units. The participants were encouraged to collaboratively work in groups of 3-4 individuals each on the various tasks during their course. The choice of members within their group was left to the participants.

Description of the study

The study was integral to teaching of the D&TE course to the participants. The course teaching included readings and discussions on the nature of technology, philosophy, influences shaping design & technology, curricular, pedagogic and assessment concerns in D&TE. The course pedagogy was designed to situate discussions and learning around tasks addressing specific objectives and was often supported with activity sheets. The activity sheets served as scaffolds, inviting participants to think about various aspects of design and technology (such as visualising structure-function relation, imagine outcomes of transformation, etc.) and extend these into realizable 'acts of engagement'. Participants reported their experiences through reflective writing and drawings, as per the specific demands of each task. Tasks served to ground 'acts of engagement' and meet the dual purpose of strengthening the knowing as well as offer exemplar, pedagogic anchors for contextual extension of understanding. The experiences through task engagements were used to channelize classroom discussions. Some tasks extend beyond classroom space as assignments which helped gauge participants' conceptual understanding and track progression in thinking.

This paper argues that the unique positioning of participants engaged in thinking about a curricular domain and its practice, afforded desirable synthesis of an organic growth of curricular activities by practitioners, a feature that Batra (2005) and Kumar (2009) argue has been missing in the Indian curricula and policies. At the same time, the study design allowed scope for participants to shift in the dynamic role of teachers-as-researchers, a knowledge perspective gaining wide acknowledgement (Kincheloe, 2003). The immersion of participants in contexts of learning posits prospects and constraints, which we need to be aware of as we discuss the insights from study.

Tasks as representative, exemplar cases

Tasks embody mindful blending of authentic teaching ideas and contextual experiences. Two tasks discussed in this paper are representative exemplar cases selected to demonstrate an authentic learning situation embodied in everyday contexts (experiencing structure-functioning of artefacts, designer-consumer relations), illustrating the continual, organic and mutually contingent relation between design and technology (appraising artefacts to re-designing) and appealing to a certain design consciousness. The learning space involving tasks encouraged collaborative work and developed an appreciation of conceptual ideas, concerns and considerations that come to play while translating teaching plans into practice.

The two tasks reported here serve as representative, exemplar cases of authentic experiences of learning and reflexive practice. Each task description attempts to capture four critical aspects, namely; reasoning the salience and intended purpose, elaboration on the nature of task, situating the task within classroom teaching-learning context, and the process of task engagement. Analysis of how tasks contributed to D&TE discourse will be discussed in the findings section.

Task 1: Invoking 'designerly' language in nuanced deciphering of an artefact

Designing is essentially situated within the context of its need. The need ought to be made explicit. Design ideas emerge and take form through an iterative process of negotiation and refinement involving the *designer* and the *consumer* (person intending to have an artefact/system). While this notion appeals to the intuitive mind, the nuances of the design process, especially those employing design language (involving sketches, models, gestures, technical detailing and material specifications) seem to remain hidden. An appreciation grounded in experiencing the mediational interplay of language in deciphering an artefact, opens to learners, the salience of *thinking in* and *through* design language.

The task was conducted with a pair of individuals (dyads), who modelled the real-life interactions between a *consumer*, whose need initiates support from the designer to arrive at a solution to the problem, and a *designer*, who uses her/his expertise to problematize the need, develop and explore potential solutions and through critical consultation with the consumer arrives at a pragmatic solution outcome. During this task, a pair of participants sat at right angles to each other (see Figure 1).

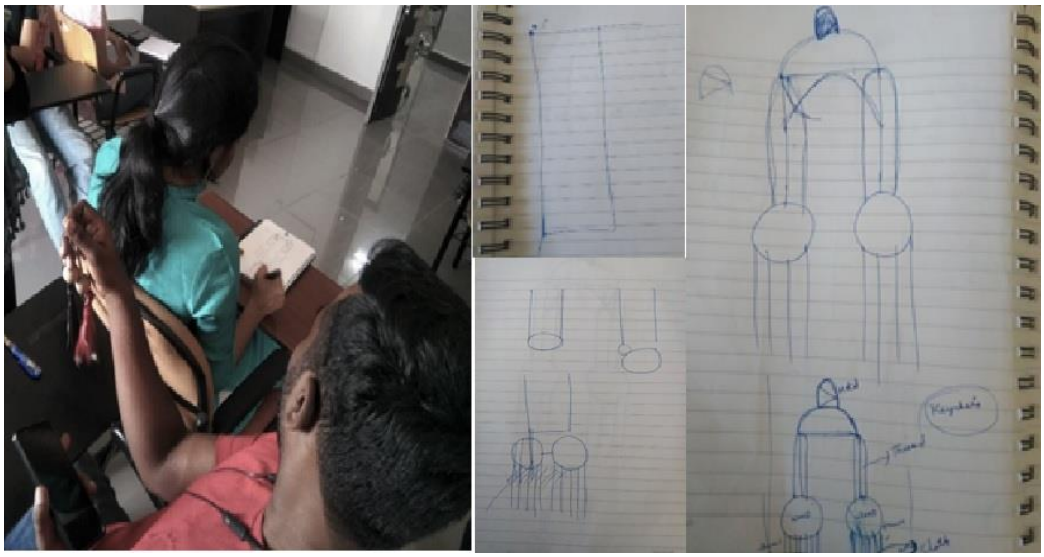

Figure 1. The seating arrangement and progressive refinement in sketched ideas about artefact.

Such an arrangement allows one of the members in the pair to be able to see, explore and describe an artefact. In the task, this person models the role of a consumer. The other partner is the designer, who is seated at right angle, cannot see, handle or experience the artefact. The designer can access the artefact through the descriptors provided by the consumer, based on which the sketch emerges. The participants were alerted to two constraints while engaging with the task. First, participants were requested not to use referential figures of speech (simile, metaphors or analogies) to describe the object. Second, they were requested not to refer to either the purpose or label (generic/ specific) the artefact. These constraints forced the participants to use technical descriptors such as shape (e.g., spherical, oblong), texture (e.g., smooth, grainy), relative size (e.g., bigger than a referent component, thinner), and so on. The systematic piece-meal reconstruction aided through sketches, talk and gestures, led to deciphering the artefact. After the designer has anticipated the artefact, s/he gets to see and handle the artefact. The temporal distancing

to knowing allows for a careful looking at nuances, much in the spirit of design being described as a 'way of looking' at the world (Thomas & Caroll, 1979).

Two kinds of discourses are embodied in the task. The first involved developing a macroscopic understanding that draws upon the philosophical and the conceptual ideas concerning appreciation of technology in everyday artefacts and the centrality of design in technology. The second or microscopic understanding relates to experiencing the strength in unpacking the descriptive process and the language in play for visualising design. On one hand, the task proffers scope for dealing with the otherwise latent ideas in a seamless, experiential and discursive manner. On the other hand, it serves for the learner an authentic, mindful and iterative context for transitioning between one's conceptual and material experiences. The task embodies the mutually contingent relation between designer and consumer, besides signifying the role of communication through the non-verbal modes, such as, gestures and sketches.

The task involved intense interactions between the partners and took 30-40 minutes. The artefacts chosen for conducting the task included ear-phone, headphone, pen-drives, notebook, key-chains, a pair of spectacles in a box, table coaster, bangle, purse, wrist-watch, etc. Some artefacts were repeated in more than one group while others had unique artefact designs to work with. Care was taken to ensure that artefact belonging to a person in a group goes to some other group, so that any form of incidental cueing elicited either through partial visualisation or handling the artefact itself is avoided. Audio-records and intermittent photographs captured the dynamics of interactions within the dyads, which served as useful means for validating observations regarding task engagement. The task encouraged participants to talk and make sketches of the artefact, allowing communicative exchange that supported the process of modelling. The productions in form of sketches became the basis for analysis.

Task 2: Analysing an artefact, critical exploration and re-designing

We are immersed in a world of designed artefacts. However, our interactions with artefacts are often not paralleled with close examination of its components, design and functioning. Philosophers have conceptualised the dual purpose of artefacts as the *proper* and the *accidental* or *discovered* purpose. Whether this idea of duality of purpose finds expression in everyday artefacts would be interesting to examine, especially among those participants who are studying about conceptualising purpose in their D&TE course. Besides, Kimbell & Stables (2007) advocate that appreciating artefacts in an informed manner is critical in building capacities towards contributing to the design and make world. Design as selective transformation of features in artefacts requires attention to details and bringing to bear the knowledge of use or handling the artefact. Further, design as problem-solving (Dorst, 2003) is foregrounded in such an orientation to the artefactual world.

This task was conducted in groups of three members each (triad). Some familiar, yet little explored artefacts from the immediate surroundings become the context for inquiry and analysis. Each group was encouraged to study five different types of water taps. Water taps are familiar artefacts and represent wide design variations. Having variants of the same artefact (tap) allowed scope for exploring and examining the material properties, intentionalities and values in design (Khunyakari, 2019). Each group examined and appraised the functioning of each of the five taps. They conjectured its *proper* and *accidental* function/s, and identified the problems in handling them. After a careful examination, the group was invited to select the most effective tap for everyday use. They had to reason their judgement. In addition, they made suggestions (textually and visually) for re-design, and elaborated their reasoning about what catalysed them to foresee a suggested change.

The task aimed to hone a certain sensitivity in carefully examining familiar artefacts and appraising the nature of functions. Such alerting to details of existing artefacts developed an interest in structure-function relations and supported reflections on immersive artefactual world. This capacity renders a

'design consciousness' and nudges individuals to notice the relevance or motivation in design problem solving. The task involved handling each artefact and noting its characteristic features. Also, relating this understanding with their own familiar experiences, the scope and urge for re-design was established. The promise of an appraisal leading to redesign seems to have much greater potential for an involved participation than merely asking for examining alternatives. The range of suggested alternatives indicated the nature of details that participants attended to and how an examination of structures extrapolated into imagining the functional artefact. The scope for visuospatial thinking does encourage mental and interactive imagery (Goldschmidt, 2001) and complex, relational mental animation (Hegarty, 1992) or seeing in the mind's eye (cognitive modelling) (Archer cited in Robert et al., 1992).

The task involved groups handling five taps and responding to the questions in the activity sheet. The questions sought to learn about their prior experience, identifying their functions and naming each tap, examining each kind of tap for its features, choosing the most efficient design and reasoning their choice, and adding features for re-designing their chosen tap, offering scope for building cultural validity about artefacts. The activity took about 50-60 mins. The task elicited a mix of drawings and written responses. Task directed individuals to attend to finer details of structure-functioning, and enabled comparisons. Features elaborated in responses to the last question encouraged correlating need and inputs for re-designing.

Data sources and processing

The activity sheets served as scaffolds to direct participants' attention to specific issues and helped in tracking progression through the tasks. Each task was done collaboratively and constituted a coherent case for analysis. Data analysed for this paper include the responses gathered through activity sheets, sketches and drawings made during the task and the audio-video data that helped capture some part of the dynamics during the task interactions. The process of data analysis involved collating, annotating and memoing the responses to each task. On a broader level, this helped identify patterns related to the nature of influences at various points of participants' engagement with the task. The pattern analysis was followed by a more detailed identification of evidences that would lead us to understand the nature of influence, kinds of strategic decisions, and gain a contemplative standpoint on the cognitive and pedagogic features of activities within each task. The analysis done at these two levels was used to create thick qualitative descriptions of participants' engagement. Insights gained from the analysis are discussed in the next section.

Analysis and findings

The data obtained from the two tasks has been analysed separately. Observations and findings from each task are followed by analytical inferences supported through evidences. In the end, an attempt is made to consolidate the insights and learning from across the two tasks.

Findings from Task 1: Invoking 'designerly' language in nuanced deciphering of an artefact

Intense and unperturbed interactions between partners in a group were observed during the task, although the classroom space exhibited a cacophony with a sudden surge in verbal exchanges. It was noted that, in general, the exchange between the designer and the consumer relied on descriptors for components, gestures for detailing features, and verbal exchanges for feedback and assertions. The progress in sketching usually began with attending to visually salient components of the artefact. For example, ear bud in case of earphones, spiral form in case of table coaster, circular dial in case of wrist watch. Interestingly, the perceptually salient features included aspects of visual appeal such as colour, texture, and shape. However, relative length dimensions (for example, cord of earphones, size of key and key-chain accessories, etc.) were compromised by the consumer and the designer. The details of functional attributes (such as key, lever for adjusting band of headphone) were discounted in favour of surface features (such as accessories, texture and colour details of ear lobes). Artistic rendering in form

of select shading or pattern differentiation was noted as a means to revising or refining part of depictions such as thickness, discriminating between the two symbol structures. Sketching thus served as a means to inquiry and marker of the inquisitive drive along with the purpose of translating imagination and detailing based on the expressions about the artefact by the partner. One notices a fluid and iterative flux between sketching and modelling, which has been observed to be critical in design and make (Khunyakari, 2015). Another interesting consistency noticed in their productions relates to the consumer's initiation into a description that maintains a flat perspective. Almost all pairs chose to describe and depict the three-dimensional (3D) artefacts in a flat plane. The only exception to this was a group attempting to capture the details of a wallet from the outside and the inside, using a relative referent of size of a hand and depicting the longer length dimension. Perhaps, the flat artefact with varying levels of accessible details forced them to opt for multiple perspectives for depiction. A reflection on experience builds an appreciation for designerly language, which is largely non-verbal.

Findings from Task 2: Analysing an artefact, critical exploration and re-designing

Analysis of responses to the activity sheet revealed interesting insights into thinking. All participants maintained that all the five taps were known and handled by them. An item within the activity sheet about the proper and the accidental function for each of the taps led to conjuring alternate imaginations or uses, some of which represented modified functionality in constrained environments (such as paper weight, for hammering, or hanging things) or a conscious extension of specific functioning (such as dispensing cold drinks and juices, regulating high pressure flows or gas pipelines). The familiarity with taps elicited experiential accounts in different settings, although not all responded to the accidental function. The labels used to differentiate the tap kinds corresponded to either structural features (e.g., two-way regulator, 4-hand tap, fat tap, etc.), settings of use (e.g., filter tap, industrial cock, bathroom tap, etc.) or an understanding of design purpose (e.g., connector, regulator, valve, etc.). Interestingly, the label kinds selected did not seem to follow a coherent scheme. In other words, a group may have labels that corresponded to structural features and settings. While evaluating features of each tap, groups examined visible components and were predominantly considered "good" features of taps. However, when they compared and reasoned about the most efficient tap, a notable shift seemed to have occurred. They moved from micro-features of handle, rubber rings, grip, etc. to macro-features like ease of handling, longevity and space. In response to the last item in the activity sheet that invited re-designing, a few interesting ideas emerged. Some such ideas included a graded flow regulated as high, moderate or no flow through a lever-lifting mechanism, a magnet-mechanism to auto-regulate flow of water from the tap. Other than these, minor suggestions of materials, handle design and filters were made. The task brought out a way of consumer negotiating needs to initiate designing and at the same time brought attention to structure functioning.

Conclusion and implications

The paper argues for the critical pedagogic role of tasks in mediating the process of knowing and learning to design and make. An illustrative elaboration of the purposes of task is achieved by discussing two tasks that were a part of the teaching endeavour involving student teachers. The two tasks served as representative, exemplar cases for analysis in order to gain conceptual and evidence-based insights from practice. The two tasks discussed facilitated noticing of structural and functional details, albeit in a qualitatively different manner. While task 1 focused on discovering design, task 2 focused on elaborating the relation to the context of its use. In both the tasks, participants employed sketching for inquiring into attributes or features rather than being directed for representation or expression alone. A question in activity sheet on features requiring transformation opened possibilities for creative expansion of knowledge about artefacts. Both tasks served as useful, experiential anchors for situating conceptual ideas in the field of D&TE. While the tasks do achieve certain immediate curricular, cognitive and pedagogic functions, the long-lasting impact gained from the experience of thinking *with* and *about* material artefacts does call for more systematic studies. The analysis revealed that participants tend to

use non-verbal communication to express ideas, largely in the form of gestures and sketches. Sketches seemed to be employed by participants as means for inquiring about artefacts rather than being used merely for representation and expression. The perceptually salient features seemed to captivate attention and greater facilitation is needed while encouraging inquiry into structural and functional aspects of artefacts. Struggle with handling conceptual categories such as the notion of accidental function or a differentiating label for kinds of tap illuminates the role of category in expanding human imagination and thinking related to artefacts. Besides, the participants tended to shift between macro and micro-features, especially when their attention was drawn to examining the structure-function relationship.

Knowing and learning through cognitive engagement with tasks offers potentials for strengthening conceptual understanding by offering authentic, practical contexts for engagement. For classroom practice, it opens up a range of possibilities that can be pursued to foreground the salience of design and make experience in a multitude of ways – cognitive, metacognitive, pedagogic and affective. As participants worked on tasks, an interplay of knowledge and skills from diverse domains created opportunities for discussing epistemic identity and also provided an inward gaze into the process of designing and the purposes of technology. Tasks afford scope for contextual and experientially informed understanding that can support preparing teachers to appreciate processes of design-and-make. More systematic efforts are needed to tease out the prospect of tasks in exploring knowing and enriching learning, especially in an experiential domain as design and technology education.

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