

# Cognitive concomitants of interactive board use and their relevance to developing effective research methodologies

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*This article addresses the need for systematic and replicable research methods for the examination of student learning using so called interactive whiteboard technologies. As a basis for these methods a model is developed of the cognitive concomitants evident in students' use of these technologies. While interactive whiteboards are shared spaces, it is important for educators to recognise individual cognitive outcomes from the interactions. Through extending an existing model of cognitive concomitants that has been used in the successful analysis of interaction in shared online discussion spaces, this paper outlines a systematic approach to the analysis of whiteboard interactions that can provide insights into the cognitive processing occurring. Recent notions of imprinting and cognitive tracks, drawn from research into online interactive behaviours, in the context of such methods, may inform the development of effective pedagogies for interactive board use.*

Interactive whiteboards, research methods, interactions, cognitions, computer mediated learning

## INTRODUCTION

From the cave paintings at Lascaux to today's interactive board technologies homosapiens have used public displays for the inscription of information, concepts and procedures. Indeed these visible boards have been historically critical for presentation to learners and to the creative processes of scientists, inventors and artists. Often such creative processes have been collaborative with the board inscribing the mutual insights of the collaborators. Until recently such boards have taken a passive role in presentation and creativity. The advent of computer supported interactive board technologies and their widespread uptake suggests new possibilities for learning and creativity with supporting computer technologies potentially enriching interactions and shared online connections expanding the notion of the publicly visible.

Various types of passive boards have long been traditional tools in the classroom with the whiteboard and marker more recently displacing the original blackboard and chalk. However, when using such boards the teacher remained at the front, directing much of the learning. With the introduction of computers there was a shift towards placing learning in the hands of the student and the teacher moving to the role of facilitator. While interactive virtual boards (IAVB) have been available for some years, (e.g. NetMeeting) more recently so-called 'interactive whiteboards' have been developed and are being adopted enthusiastically by teachers, schools and education systems. To avoid confusion we describe the latter as computer supported interactive physical boards (IAPB) and refer to both jointly as interactive boards. IAPBs allow participants to interact directly with the board assisting a more student-centred approach to learning. Despite this both interactive boards also allow teachers to develop more engaging presentations and re-assert teacher centred practices. Of critical importance in the uptake of these interactive boards is the extent to which student learning actually occurs when students

themselves use them. However while there is much literature on case studies of student use with IAPBs (Curhell, n.d.; Glover, Miller, & Averis, 2003; Lee & Boyle, 2003) there is a lack of systematic and replicable studies that actually demonstrate student learning, linking it to the specifics of student interactive board activity and theoretically underpin findings in our current understanding of cognition and learning. There is thus a need to develop research methods for interactive board use that have a firm basis in learning theory and that can establish findings capable of informing teacher pedagogical practice.

### **INTERACTIVE BOARD TECHNOLOGIES**

It is important to consider the interactive boards in relation to their passive predecessors. There has been a tendency for passive boards to be more the domain of the teacher and not used extensively for student interaction. Where such boards are shared it is necessary to adopt agreements or practices that address processes for board use. Agreements about erasure are a definite consideration. Courtesies and consideration of other user practices will be important. For multiple users, agreements about writing and erasure can be quite complex. Such agreements, tacit or otherwise, could be considered as ‘protocols’ governing board uses. There will be at least an equal need for analogous protocols in the shared use of interactive whiteboards. Such protocols ensure that teachers can focus on their teaching and student learning.

Researchers have tried to understand the variables in classroom instruction and have found that teachers have a significant and lasting impact on student achievement (Rivers & Sanders, 2002 cited 2006). Wenglinsky (2002) also found that student learning was “a product of interactions between students and teachers with both parties contributing to the interaction”. He suggested that classroom practices had the greatest effect on student performance which supported the importance of utilising effective pedagogies. Hence IAPBs, which have found their way into classrooms, may offer the capacity to enhance teaching supported by effective instructional practices. They are able to offer specialised utilities that can scaffold teaching, such as screen highlighting, moving objects around and printing the screen, thus expanding on the teacher based instructional effectiveness of traditional passive boards.

The growing recognition of the value of computer supported interactive whiteboards in the classroom led to the development of specific classroom software for various curriculum areas which helped to optimise student participation. The multiple representations and explicit modelling cater for the range of learning styles evident in every classroom. A primary benefit of IAPBs in the classroom is the students’ increased motivation due to their presentation capabilities, their high level of interactivity and their capacity to present and discuss students’ work. (British Educational Communications and Technology Agency (BECTA), 2003). Qualitative research currently suggests that the use of IAPBs has a positive impact on student engagement and hence on student achievement (Beeland, nd, cited in Tom Snyder Productions, 2006). Thus there is a need to develop pedagogies that exploit interactivity (Glover et al., 2003). Some notable outcomes of investigations through observation and videoed lessons into the use of interactive whiteboards (Glover et al., 2003) showed that students became attentive immediately the teacher spoke suggesting that students had little opportunity to move off-task when using IAPB (observed pupils were seen to be ‘on-task’ on average for 87% of the time). Further observations also indicated that effective use of IAPBs is still in its infancy. With increased experience, teachers will be able to match their teaching methods with students’ learning styles and will be more fluent in managing episodes of interaction within the focus of the lesson duration.

A further study on the use of IAPBs (Miller, Glover, & Averis, 2004) suggested that there were three major features that encouraged student motivation and these included, intrinsic stimulation, sustained focus and stepped learning. Intrinsic stimulation came from the dynamism and attraction of the lessons which resulted in neater exercise books, greater use of colour and presentational techniques not previously seen with more conventional boards. Sustained focus was possible because of the constant interactivity that was occurring which maintained the pace

of the lesson and helped students to stay on-task. Stepped lessons were possible with the ready recall of previous lessons which allowed a revisit of earlier concepts to strengthen understanding. The immediacy of the responses and fewer behavioural issues were recognised as further benefits.

While it would appear that IAPBs are a powerful teaching tool there are practices that underpin their effectiveness. Research by BECTA (2005) has identified a number of tips on how to use interactive boards effectively. However, it would appear that there are other interaction protocols that also need to be identified, such as, who has the right to erase another student's work or make changes, whether minor or major. Other considerations include the management of the interface and function and skills with the tools.

There is no reason why such physical interactive whiteboards are limited to a single classroom, some versions allow multiple computer input and some allow internet connectivity between multiple boards, considerably expanding the number of interactive modes and transcending the distances between users.

The shared online interactive virtual boards, which may also be referred to as a conferencing board, offers an online environment where participants from multiple locations can communicate and develop their ideas cooperatively or collaboratively. Typical products of this type are NetMeeting and Centra, where the board display is combined with conferencing tools. Various aspects of these three technologies are summarised in Table 1.

**Table 1. Comparison of various whiteboards**

	Passive Board	Computer Supported Interactive Physical Board (IAPB)	Computer Supported Online Interactive Virtual Board (IAVB)
technology	passive board	physical active board	online virtual board and conferencing
typical product		ActivBoard, SmartBoard	NetMeeting, Centra
basic writing and drawing tools	colour markers, erasers	physical colour pens, physical erasers and virtual pens and erasers	cursors, virtual colour pens, virtual erasers
the shared space	the display surface	the screen of a computer shown on the board surface	application windows displaying a board and conferencing components
other interactive modes	face to face	face to face or online through multiple boards and computers	conferencing tools, chat, email, video, voice
advanced writing and drawing	none	software supported visual effects, OCR	software supported visual effects
other resources		digital pictures, sound and maps etc. on board	files and applications not on board
teacher presence	nearby	nearby and/or on computer	lurking or participating online
archiving	no facility	stored screens and saved files, no direct facility for capturing discussion	archives of conferencing, stored screens

Participants in online environments may not know each other personally nor be privy to the body language of the other person. IAVBs will be successful as a collaborative tool once certain protocols have been established that thus require the identification of common ground. After a basic introduction, if needed, certain codes of behaviour need to be established to ensure successful collaborative goals are attained. Once such awareness has been established a number of participants can work together successfully on ideas and design.

The virtual environment allows each user to act independently with the shared space that may only take up a part of the user's screen. A sense of common intent may be absent due to the proliferation of application windows and non-board applications. In order to improve this sense of immersion investigations have been undertaken in the use of avatars to identify users in this virtual setting where the goal is to provide a convenient environment for participant interactions (Tseng, Shae, Leung & Chen, 2001). IAVBs in such an environment allow users to interact with their virtual applications. The board behaves as a display surface and responds to pen strokes

which may be more comfortable for users who struggle with the rigidity of computers. For some applications the whole board session can be recorded and later replayed to show users how they arrived at the design that was finally generated.

In order to understand better the difficulties encountered in shared spaces it may be convenient to discuss the use of the shared interactive boards in the context of an exemplar task and learning purpose. Consider children being given the task of designing a house using a white board. The task may be, at least initially, that each student should design their own room in various parts of the board and bring these together to form a workable house. As part of the task students will need to discuss and negotiate roles. There should be learning outcomes for students in terms of scale and measurement, design, living skills, sustainability and basic science (among others). When discussing the design students need to ensure that they are talking about the same room or area of the house. There may be a need to indicate who has the control for a particular period of time. The establishment of early protocols will allow students to attain their final goal more successfully and efficiently.

With the evolution of new technologies there is much to learn about effective pedagogies that will ensure enhanced learning for the student. Further development of such pedagogies comes from an investigation of the learning theories and research literature on the value of interaction, collaboration and cognition in learning.

### **THEORETICAL UNDERPINNINGS**

This article draws on both cognitive and social constructivist learning theories with cognitive constructivists focusing on the individual and thought processes of the mind and the social constructivist emphasising the impact of social and cultural contexts that take into account other people's perspectives in their learning. Henri (1992) and Garrison (1992) have outlined models with discrete indicators that provided guidance on identifying cognitive learning processes, with consequently less attention to the type of interaction occurring. Hence the need to consider the social constructivists' interest in the interactions that support the learning.

Research into learning has shown that students learn best when they are actively engaged with the content and build their own knowledge based on prior experience through interaction with the social environment (Anderson & Garrison, 1995). Through interaction and collaboration, learners can discuss, interpret and negotiate, so that together they co-construct their understanding. This is made possible through the use of interactive technologies where through collective efforts students can create exciting learning experiences. Learning occurs when participants are active in shared activities while bringing different experiences and perspectives into the socio-cultural context.

The theory of social interdependence (Johnson & Johnson, 1996) emphasises the importance of relationships within groups. It identifies the types of relationships that should be encouraged and fostered in cooperative environments where higher order cognition is a desired outcome. A supportive community where strong collaboration is evident will more readily integrate learners from diverse backgrounds. Learners are more likely to be motivated and committed if they experience constructive encouragement and support. Such theories recognise the potential of technology to support interactive and collaborative activities.

Interaction and collaboration are considered key ingredients in both the traditional classroom and in online learning communities and can have powerful influences on learning (Gilbert & Moore, 1998; King & Doerfert, 1996). Interaction can be defined from many perspectives and takes on new dimensions with the emergence of interactive technologies, such as shared and interactive whiteboards, which add to the complexities of devising suitable pedagogies. Dynamic interactions support learners in their development of higher order cognition. An analysis of cognitive development provides insight into the quality of the learning outcomes. Insight into the learning occurring when using various interactive boards may be gained from the research on shared discussion spaces and on technologies for collaborative activities.

### **INVESTIGATIONS OF INTERACTIVITY: THE EXAMPLE OF SHARED EMAIL DISCUSSION FORUMS**

An investigation of the discourse of approximately 275 students across 15 discussion forums in a first year teacher education course found that students exhibited consistent interactive behaviours (Geer, 2005b). In this study students were required to respond to four classroom related topics through the discussion forums held at various times throughout the semester. In order to analyse the behavioural and cognitive interactivity that was occurring in the discussion forums an evaluative tool, 'A Model for social behaviour, cognitive development and interactive analysis' (SCIA), was developed by Geer (2005) to assist in the analysis of archived discourse. This model originated from a tool used by Gunawardena, Lowe and Anderson (1997) who drew on Henri's (1992) and Garrison's (1992) cognitive indicators of critical reasoning and thinking to examine the social construction of knowledge in computer conferencing. Such indicators provided a reliable basis for examining the cognition of digital archives no matter what the technology. However, it was recognised that different technologies may require an expansion of the indicators to identify interactive and cognitive behaviours specific to the characteristics of the technology.

The model, SCIA (Table 2 – non-asterisked items) proposed that certain types of interactive behaviours could be extracted from the digital archives which captured the learner's sense of social presence and their learning preferences as they discussed the four topics in their first year course. Thus by utilising SCIA an analysis of the discourse showed that students tended to adopt a particular type of orientation (social, individual or group) in their first interactions, and which was repeated in their future interactions. From an analysis of the discourse it was possible to determine whether the students were responding as individuals or whether they acknowledged others in the forum and saw themselves as being part of a group. Those students who were group oriented also tended to be more social. Students with an individual orientation adopted an approach that saw them contributing to the discussion but with no appreciation of being part of a group. They had less understanding of using multiple perspectives to build their own understanding. Overall, the communication patterns established in their first interactions appeared to flow through to other interactions.

The effect of initial communication patterns being replicated in subsequent interactions led to the notion of 'imprinting'. Hence initial communication patterns are shown to be powerful in determining subsequent interactive behaviours in the forums. The effects of imprinting then become a consideration in the formation of discussion forums or online learning communities. This has implications for the instructional design where interaction is encouraged and particular outcomes required. Therefore the research highlights the importance of developing appropriate pedagogies to ensure that desired learning outcomes are evidenced in the first interactions. Time must be spent ensuring that students understand clearly the purpose of the interactions. There was also sufficient evidence from the investigation to suggest that imprinting may be a valid predictor of students' academic achievements (Geer, 2005b).

Using the evaluative model, SCIA, the discourse was also analysed for evidence of cognitive indicators. An analysis of cognitive development provided insight into the quality of the learning experiences. A pattern of indicators emerged which showed the development of what has been referred to as cognitive tracks as successive learning-related cognitions (Geer, 2005a). A canonical correlation analysis was performed between cognitive indicator on Topic 1 and the aggregated scores on the other three topics (Geer, 2005b). Further examination of the cognitive indicators showed that students appeared to exhibit particular interactive and cognitive behaviours over time. The cognitive levels achieved in the first response were predictors of cognitive levels achieved in later responses.

**Table 2. A model for social behaviour, cognitive development and interactive analysis in interactive board use**

<b>S. Participation and social behaviour</b>	S1 Individual disclosure	S1-a Basic introduction. S1-b Extended revelation S1-c Self evaluation
	S2 Social behaviour	S2-a Courtesy S2-b Level of dominance/authority S2-c Seeking help S2-d Willingness to initiate
	<b>S3 Common Ground *</b>	<b>S3-a Agreed purpose</b> <b>S3-b Speaking the same language</b> <b>S3-c On the same page</b> <b>S3-d Distinguishing work level and meta level</b>
	<b>S4 Protocols *</b>	<b>S4-a Distribution and ownership of work</b> <b>S4-b Indicating assent and understanding</b> <b>S4-c Assigning tool control</b>
	S5 Mutual Consideration	S5-a Identifying mutual interest S6-b Willingness to exchange S6-c Valuing others' views
<b>I. Cognitive behaviour analysis at individual level:</b>	I1 Elementary clarification	I1-a Observing/studying a problem I1-b Identifying its elements I1-c Observing/studying their linkages
	<b>I2 Computer Tools Competence*</b>	<b>I2-a Understanding and managing the interface</b> <b>I2-b Appreciating the functions of tools</b> <b>I2-c Transparent skills with tools</b>
	<b>I3 Elementary Contribution*</b>	<b>I3-a Initiating a contribution</b> <b>I3-b Making changes</b> <b>I3-c Minor additions</b> <b>I3-d Major additions</b> <b>I3-e Extensive changes</b>
	I4 In-depth clarification	I4-a Analysing a problem I4-b Identifying assumptions I4-c Establishing referential criteria I4-d Seeking out specialized information <b>I4-e Thematic changes and additions*</b>
	I5 Synthesis and application	I5-a Drawing primary conclusions I5-b Proposing an idea based on links and relevant information I5-c Value judgment on relevant solutions I5-d Making final decisions and deciding on the action(s) to be taken <b>I5-e Suggesting protocol changes and new common ground*</b>
<b>G. Interactive and Cognitive behaviour analysis at group level:</b>	G1 Planning	G1-a Organizing work/planning group work/setting shared tasks G1-b Initiating activities/setting up activities for group work <b>G1-c Setting protocols*</b>
	G2 Sharing/ comparing/ contributing of information	G2-a Defining and identifying a problem G2-b Stating opinions regarding the problem G2-c Asking and answering questions to clarify details of statements G2-d Sharing and exchanging knowledge, resources and information G2-e Corroborating examples provided by one or more participants G2-f Challenging others to engage in group discussion G2-g Help and feedback giving <b>G2-h Identifying and discussing common ground*</b>
	G3 Inconsistency of ideas, concepts or statements	G3-a Identifying and stating areas of disagreement G3-b Asking and answering questions to clarify the source and extent of disagreement G3-c Restating the participants' position and advancing arguments supported by references <b>G3-d Recognising and communicating differences about protocols*</b> <b>G3-e Recognising and discussing new common ground*</b>
	G4 Negotiation of meaning/ co-construction of knowledge	G4-a Negotiating the meaning of terms, areas of agreement and disagreement G4-b Proposing new statements embodying compromise and co-construction G4-c Integrating or accommodating metaphors or analogies <b>G4-d Negotiating new protocols and new common ground*</b>
	G5 Testing and modifying of proposed synthesis or co-constructing knowledge	G5-a Testing against existing knowledge and information G5-b Testing against personal experience G5-c Testing against formal data collected
	G6 Agreement statement(s) and application of newly constructed knowledge	G6-a Summarization of agreement(s) G6-b Application of new knowledge <b>G6-c Statement of new common ground and protocols*</b>

\*New indicators appropriate to interactive boards denoted with asterisks in bold type

The pattern of indicators provided insight into the type of cognitive track students had adopted while further supporting the notion of imprinting. Two types of imprinting were evident with some students manifesting the dominance of one particular cognitive indicator over time and across interactions. This type of track was referred to as a static and narrow cognitive track, while others demonstrated a set of cognitive indicators for each topic that were repeated for subsequent topics, referred to as static but broad. Where imprinting may not be a desired outcome a dynamic and broad cognitive track may be a preferred outcome with students moving through various cognitive indicators that indicate students are utilising differing strategies and developing further cognitive skills over time.

It is an important finding that such a methodology and analysis provides educators with the opportunity to influence students' cognitive behaviour (Geer, 2005b). From a teaching and learning perspective this implies that the cognitive behaviours that occur in the first topic therefore need to reflect the desired learning outcomes, if the discussion forums are to meet course objectives. Educators need to be clear about the purpose and the type of interactions they wish to encourage and the desired outcomes including cognitive development. Educators must build into the design strategies that will ensure desired outcomes are evident. Thus the notion of 'imprinting' assumes the need to 'get it right' from the start to ensure cognitive development is supported and sustained. This then has implications for the instructional design where scaffolding and modelling are critical to ensure adoption of a suitable cognitive track that supports cognitive developmental processes over time.

Such findings have possible implications when using other types of technologies including board technologies. Careful consideration needs to be given to the development of practices and protocols that ensure participants understand suitable interactive behaviours that can further the cognition of students. Hence relevant indicators need to be identified to ensure effective use of the technology leading to desired learning outcomes.

It is significant to note that the notion of imprinting is not confined to the types of interactions and cognitions that students experience but also to the actual choice of technologies in group work contexts. Huysman, Steinfield, Jang, David et. al. (2003) found that the type of technology used by students for early collaborative tasks continued to be used throughout their interactions. Students exhibited a type of media 'stickiness' related to the initial choice of and competency with interactive computer tools.

### **EXTENDING COGNITIVE ANALYSIS OF DISCOURSE TO INTERACTIVE BOARD TECHNOLOGIES**

The foregoing suggests that an analysis of the discourse generated in use of interactive board analogous to that of SCIA may provide a clearer picture of the learning occurring as well as be suggestive of pedagogical strategies that might optimise that learning.

Interaction has been shown to be critical in effective teaching and learning. However, it is important to go beyond the mere acknowledgement that interaction is occurring and analyse its impact on learning and the cognitive development of the individual. It is important that processes be examined that help students to arrive at the end product rather than just attain the end product itself. Analysing these processes at the group and individual levels is often very difficult, time consuming and costly thus highlighting the importance of instructional design and the achievement of desired learning outcomes from the beginning.

The above research points to the importance of establishing protocols or strategies that will support students in their collaborative interactions. Educators must be able to model good practice and provide sufficient scaffolding that will enable students to attain the learning outcomes. Also it may be important to establish certain protocols from the start to ensure the effectiveness of the various tools. Although interactive boards have been around for a long time and certain implicit protocols are evident this does not necessarily mean that established protocols will necessarily be applied to online and varied forms of interactions. Good practices need to be developed and

established to ensure that the greatest benefit is gained from the use of these tools and that good habits are established allowing for higher cognitive development and more collaborative interactions. For example there are certain board etiquette rules for the passive board which need to be followed to enable learning to occur for other users, for example, don't use permanent markers or tape things to the board as it can ruin the surface, and also you should erase your work once it is no longer needed; just to name a few. By abiding by such simple principles time can be saved and learning can occur. If such rules are not established from the beginning bad habits can form which affect the effectiveness of the tool and the efficiency of the teacher. The establishment of such protocols become more critical in the online environment where students do not know each other and assumptions cannot be made that participants are talking about the same aspect.

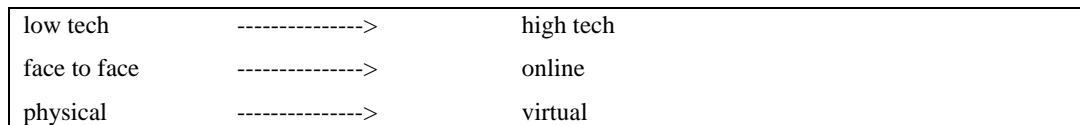
Research is still very much in its infancy when considering the type of modelling and etiquettes relevant to the various interactive board technologies. There exists a further challenge in establishing appropriate strategies that will allow higher cognition to be present in online interactions. The logging of the individual interactions would provide some indication of the cognitive development but this appears to be more complex than the recording of textual exchanges in a discussion forum. Hence this emphasises the importance of establishing clear goals and ensuring that there is some likelihood of these goals being achieved from the outset.

Based on the studies that have raised the notions of imprinting and cognitive tracks, consideration must be given to establishing appropriate practices before the initial interactions. Protocols should be instigated from the outset to ensure that the full benefits of interactive technologies are attained. Established patterns need to be set early because they may be difficult to change later on.

**A NEW MODEL FOR INTERACTIVE AND COGNITIVE CONCOMITANTS  
OF INTERACTIVE BOARD USE**

Successful application of SCIA in a number of different technological contexts suggests its value for developing a model for interactive board use. Observation and initial research in the use of interactive boards implies the need for additional indicators to be presents in a new form of SCIA appropriate to such technologies. The use of SCIA with the addition of indicators for board use may offer further insight into the development of research methods when using various technologies.

Designing a model that extends beyond email discussion to tools such as interactive boards and preserves a linkage from the discourse generated to the implied cognitions and learnings is a considerable challenge. A convenient artifice is to consider all three boards (passive, IAPB and IAVB) as positioned along a number of dimensions such as technology complexity, proximity and virtuality (as in Figure 1).



**Figure 1. Dimensions for considering boards**

As the proximity of participants moves from face to face to online there is increasing reliance on various technologies to carry the communication. Hence what was once perhaps implicit in face to face interactions may need to be made explicit in online interactions. Aspects of the social interaction such as dominance and courtesy may need direct attention. At a deeper level it will be important to be clear on the common ground of the participants, hence the need for a new section on common ground S3. The purpose needs to be mutually agreed (S3a) and the language needs to be the same (S3b). A given individual needs to know what another is alluding to. As the board itself has more items on it, uncertainty about the intention of others can grow. With the use of off-board applications (e.g. WWW), confusion about "being on the same page" (S3c) both conceptually and physically can abound. Importantly participants need to be able to draw



attention to such matters and be able to discuss them. Hence they need to be able to recognise what the exchange has to do with the work and purpose, or how to proceed, and what is the basis of agreement (the meta level) (S3d). Inability to attend cognitively to the meta level will stymie higher levels of interaction such as cooperation and collaboration. It is important not to see 'common ground' as a 'given' at the beginning of the interactions but as a dynamic and growing aspect of the interaction. As interaction (and perhaps collaboration and cooperation) proceeds mutual understanding of what has been achieved should grow.

Another critical feature of IAPBs and IAVBs is the need for agreed protocols, hence the new section S4. Some of these relate to uses of the tools such as erasers but agreed protocols about eraser use becomes much more critical in a more virtual environment, where capacity totally to erase is a click away and in a more online environment where one participant cannot physically stop another from an action. Protocols may need to be in place about the divisions of work and tasks (S4a). They are also needed in relation to the ownership of work and the related nature of assessment (group, individual, etc.). Participants need agreed signals for indicating assent or non-assent and understanding or misunderstanding (S4b). Such protocols can more easily be established in the face to face mode than online. Participants also need protocols about tool use and transfer of control (S4C).

Individual participants using whiteboards need some basic skills in tool use, hence section I2. As these tools become more virtual the degree of skill needed to achieve the same result generally becomes higher and will require an understanding of the function of the tool (I2b). However, many more extensive tools are available, some such as copy and paste with no analogue in the passive board. Importantly successful interactions will occur for IAPBs and online IAVBs when all participants' skill levels move beyond a threshold to become routine and transparent to the task involved (I2a, I2c).

Through the use of tools participants will actually demonstrate their understanding of the task and the purpose, hence section I3. Elementary contributions ranging from minor to major changes (I3b, I3e) and additions (I3c, I3d) should be visible in any archived history of the board. Some whiteboards such as Centra support a form of archiving. But deeper understanding of task would be demonstrable with thematic changes. In the context of our example of participants each designing a room of a house, a thematic change might be the repositioning of the rooms and adjusting window positions to give the bedrooms the morning sun. Finally in terms of individual cognitions, suggestions for protocol changes and restatement of newly developed common ground indicate deep levels of synthesis and integration.

Similar sorts of indicators should be evident in interactive behaviour that are more the results of group rather than individual effort (hence G1b, G2h, G3d, G3e, G4d, G6c). In our house example a group outcome might be the relative position of participants rooms around the hall and corridors, ensuring adequate distance of bedrooms from entertainment areas. Such changes may require individuals to reduce their aspirations for door and window positions and negotiate with each other. The capacity of the group to set up new protocols and agreeing on new common ground (e.g. no bedroom adjacent to the family room) may be critical. The new common ground is indicative of a new learning about the house as a social space not just a collection of individuals and their bedrooms Teachers who are alert to evidence of G4d and G4c in the discourse of participants are more likely to be assured that such learning has occurred.

## CONCLUSIONS

An attempt has been made to develop a model of the cognitive concomitants of students' use of interactive board technologies. As these technologies populate our class rooms and become important in distance education, teachers will need ways to assure themselves that they are achieving the desired levels of interaction and the targeted learning outcomes. They also need to be assured that their pedagogical approach is successful and they are achieving the type of interactive learning desired. We know, however, that higher levels of cooperation and

collaboration are difficult to achieve and that group activities make it difficult to see if individual learnings are occurring. Whole group outcomes may be evident in the final board result but it will be impossible to untangle individual cognitions without examining the interactions among participants. The approach above provides a useful model for examining this discourse of interaction. Indicators of certain cognitions should be evident in the interactive discourse. Certain key indicators appear to be critical for performance within specific interactive pedagogies. The absence of these indicators within the early interactions of participants should be a signal to teachers that their direct engagement in the process of learning is needed. The dangers of imprinting and media stickiness may jeopardise creative use of these technologies.

The model is also useful in helping to frame a discussion of the many unanswered questions about board use. How do imprinting and media stickiness manifest themselves with these technologies and what teacher practices should be adopted? How do we best support the development of effective protocols and a sense of common ground in online environments? To what extent do these agreements need to be explicit or implicit? The focus on specific cognitions also allows us to discuss developmental capacities of children to use such technologies. Can junior primary students actually achieve a group orientation and whole group learning outcomes? What social skills are needed for successful participant engagement and what are the specifics of the successful protocols. Do imprinting and stickiness impact on younger children to the extent they appear to do on adults? What is the impact of off board activities on the sense of common ground in the online domain? The full realisation of the extensive possibilities felt by many teachers for interactive board technologies awaits a systematic program of research into these and other questions.

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