

The 'copy and paste' function: A flawed cognitive tool in need of redesign

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This paper argues that the traditional version of the 'copy and paste' function used in many computer-mediated learning environments is a flawed cognitive tool for learning applications and may in fact subvert the constructivist philosophy of many learning packages. An initial study was conducted, using distributed cognition theory to redesign the interface of the 'copy and paste' function, to examine the efficacy of embedding a specific interaction strategy (reported in Morgan et al., 2006a, 2006b). The embedded interaction strategy involved summarisation note taking tasks and the results of this empirical study are outlined in order to establish the efficacy of this approach. This paper goes on to argue that this principle can be extended to include a wider variety of interaction strategies designed to invoke different encoding techniques (Lutz, 2000), including note taking, categorisation and concept mapping. By embedding different interaction strategies into the interface of the 'copy and paste' function an effective processing strategy emerges as a consequence of employing the tool. In addition the learner is exposed to a range of processing strategies and may become conscious of choosing the appropriate interaction strategy for the specific task at hand, thereby improving their metacognitive skills. A series of further studies are advocated to examine the effects of the approach that has been outlined.

Keywords: distributed cognition, mediating artefacts, cognitive tools, constructivism

Background

The constructivist multimedia package *Exploring the Nardoo* (Interactive Multimedia Learning Laboratory, 1996), which explores water management, quality and environmental issues, was the original context of an initial study of the 'copy and paste' function (reported in Morgan et al., 2006a, 2006b). *Exploring the Nardoo* (Cordorey et al., 1998; Harper et al., 2000), is organised around a number of investigation projects and simulations, focusing on water quality and usage, and employs a virtual information landscape of an inland river system in which a variety of resources, including audio, video, graphics, texts and simulations, are embedded. In this initial study concerns were raised that the traditional form of the 'copy and paste' function subverted the constructivist philosophy of the package. Extensive text-based resources are embedded in the *Exploring the Nardoo* package and the learner is provided with a range of tools, a PDA (Personal Digital Assistant) Notes Module, a TextTablet, genre templates and note taking resources, to assist them in processing this content. Previous studies of the *Exploring the Nardoo* package have indicated that some learners found it difficult to synthesize a response from the abundance of information available while others had problems editing out redundant material in order to produce concise responses targeted at the investigation topic. For example:

... one teacher believed that the students collected all the relevant resources but felt that, when it came down to putting it together and making all that abundance of information something more concise, the students had difficulty. She explained that even though she reminded her class "don't just copy slabs of information and regurgitate it in your report, make sure you read it, understand it, relate it to the question", based on the students reports presented, she felt that she could have reinforced this concept of analyzing the information more (Hedberg et al., 1998, p. 3).

The authors have argued (Morgan et al., 2006a) that the doubts raised by teachers are directly related to the functionality of the Notes Module of the package with its traditional 'copy and paste' function in that

this tool does not seem to complement the constructivist principles of the learning environment. In its traditional form the 'copy and paste' function allows learners to import text into a document in a form that may be formatted in a way that is not visually distinguishable from their own work and that does not necessarily include pointers to its original context and/or authorship.

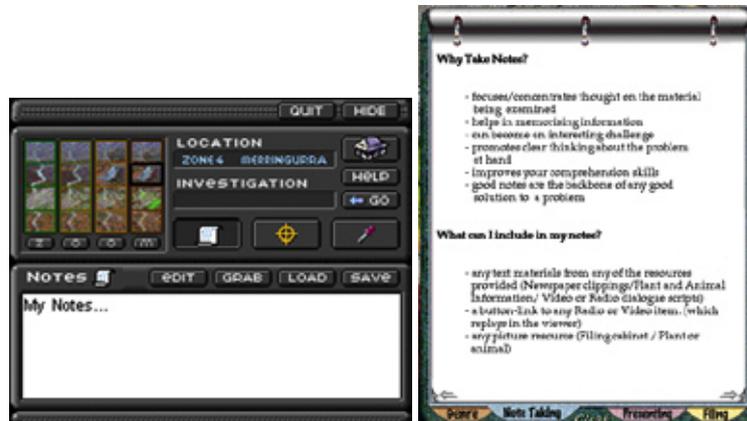


Figure 1: Exploring the Nardoo: Notes module and note taking advice

The 'copy and paste' function can be seen as an example of a cognitive tool (Jonassen, 1996; Jonassen & Reeves, 1996; Lajoie, 2000; Lajoie & Derry, 1993) which can be used as a 'knowledge construction implement' that assists learners to reflect on meanings and articulate their understandings. The cognitive tools approach uses commonly available software tools to:

- empower learners to design their own representations of knowledge rather than absorbing knowledge representations preconceived by others.
- support the deep reflective thinking that is necessary for meaningful learning (Jonassen & Reeves 1996, p. 698).

However, the development of the 'copy and paste' function in a business context has led to an arrangement of affordances and constraints which increase the speed and accuracy of information reproduction. These affordances and constraints may be problematic when this tool is applied to a learning task.

Activity Theory (Engeström, 1998; Nardi, 1996a), proposes that artefacts carry with them, in their form and function, the history of their development and use. In other words, encoded within their form are specific ways of acting and thinking, which influence those who make use of these tools. Generic tools may be inappropriate for some learning tasks or in some cases could be easily modified to produce more effective learning outcomes (Morgan et al., 2006a).

In this interaction little guidance or support is provided to the learner on effective methods of using appropriated content and the affordances and constraints of the traditional 'copy and paste' function may in fact subvert the constructivist learning objectives of the interaction.

Distributed cognition theory

Vygotsky (1980), has argued that the cognitive processes of humans are to a large extent enabled and shaped by artefacts from the cultural context. This concept differentiates distributed cognition (Cole & Engeström, 1993; Cole & Wertsch, 1998; Dillenbourg, 1996; Engeström, 1999; Hutchins, 1995; Hollan, Hutchins & Kirsch, 2000; Karasavvidis, 2002; Nardi, 1996a, 1996b; Pea, 1985, 1993; Perkins, 1993; Salomon, 1993; Wertsch, 1985) from other theories of cognition such as information processing theory (Atkinson & Shiffrin, 1971; Lutz, 2000; Miller, 1956; Sweller, 1999). Information processing theory is generally concerned with the means by which stimulus is processed internally by the individual. The

significant events in the cognitive process are seen to be internal to the individual and therefore, the outcomes of cognitive activities are determined primarily by the internal resources of the individual.

In contrast, distributed cognition theory conceptualises the mind as a node embedded in a mesh of social and cultural relationships.

Minds are not passive representational engines, whose primary function is to create internal models of the external world. The relations between internal processes and external ones are far more complex, involving coordination at many different time scales between internal resources—memory, attention, executive function—and external resources—the objects, artifacts, and at-hand materials constantly surrounding us (Hollan et al., 2000, p. 177).

A valid outcome of cognition in terms of distributed cognition theory may involve the successful utilisation of resources in the environment, or the adaptation of a mediating artefact to a new context or purpose, or even the fixing of a successful pattern of cognition or activity into a new mediating artefact.

... because what we call mind works through artifacts it cannot be unconditionally bounded by the head nor even by the body, but must be seen as distributed in the artifacts which are woven together and which weave together individual human actions in concert with and as a part of the permeable, changing, events of life (Cole & Wertsch, 1998, p. 3).

The arena for examining issues of cognition is therefore changed from the concept of the mind in isolation, planning actions and evaluating experiences, to the mind situated and enmeshed in a context.

Interaction strategies provide a good example of the fact that the resources that shape and enable cognitive processes are not limited to internal cognitive resources and may be derived from a variety of sources. Vygotsky (1980), with his concept of the Zone of Proximal Development, has already pointed out the important role of parents in structuring and enabling the cognitive activities of children through a process of assisted dialogue which is later represented in the adult primarily as internal resources for thinking. Wright et al. (2000), point out that all activities require a range of 'resources for action'. These resources not only influence the nature of the activity but also the nature of the cognitions that occur during that activity. Interaction strategies, structures that control action, are probably the most important category of the 'resources for action' discussed by Wright et al. (2000) but they are only one example of the resources for cognition that may be distributed between the internal and external components of the system.

In terms of distributed cognition theory the actual source of the interaction strategy, whether internal or external, is not as important as its access characteristics. Access characteristics, or the cost of access, may be assessed from a variety of perspectives. These include the reliability of access, the ease with which it is employed, and the cost in internal cognitive resources of accessing and using the resource. All internal and external resources will have a variety of costs and benefits. The question is which method is most effective in learning contexts? In particular when using the 'copy and paste' function which method will be most effective in assisting the learner to process content effectively for understanding between:

- 1 Relying on the learner to remember and implement a processing strategy which they have already 'learned'
- 2 Relying on an instructor to tell them which processing strategy to use,
- 3 Representing the processing strategy in the environment in the form of a plan which the learner then follows, such as a worksheet, set of instructions or task list,
- 4 Embedding the processing strategy in the interface of a tool so that its affordances and constraints guide the learner when it is used to work with the content.

In addition could inappropriate processing strategies that are already embedded into a tool have a large effect in undermining the effectiveness of the first three sources of processing strategies in learning environments?

These questions were investigated in an initial study of the ‘copy and paste’ function. The results seem to indicate that embedding an interaction strategy into the interface of a tool may be more effective than resources represented in the environment in the form of a plan for action or relying on internal resources to remember and implement the appropriate interaction strategy. In addition inappropriate strategies that have unintentionally been embedded in the interface due to the historical development or context of the tools creation may work to subvert more effective interaction strategies that are represented in the environment as a plan or that are supplied by others or that have been learned. An example of this is seen in the ‘copy and paste’ function where its original context of development in business applications has led to a set of affordances and constraints being built into the tool which may not be appropriate for learning activities. The traditional form of the ‘copy and paste’ function may be undermining attempts from various sources to implement more effective interaction strategies.

The redesigned ‘copy and paste’ function

The aim of the initial study in redesigning the ‘copy and paste’ function of notepad tools, such as those found in the *Exploring the Nardoo* package, was to change the order and manner in which the learners carry out learning activities so that they can be supported in their attempts to form an effective distribution of cognitive activities when using this tool.

A careful examination of the ‘copy and paste’ function has led the researchers to the conclusion that the constructivist theoretical base on which the package is built is undermined by the provision of a notepad tool that:

- 1 Makes it easy to appropriate the information ‘as is’.
- 2 Separates the processes of exploring the information landscape and gathering resources, and the process of making a response to those resources via a project, report or presentation.
- 3 Does not make explicit the difference between the learner’s original work and the resources gathered from the environment (Morgan et al., 2006a).

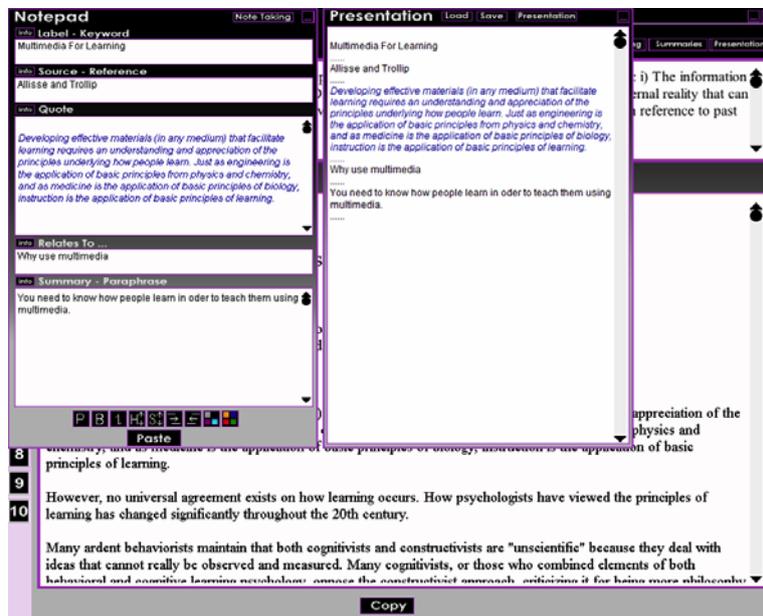


Figure 2: The modified version of the ‘copy and paste’ function

Figure 2 shows the interface of the redesigned ‘copy and paste’ function used in the initial study in the form of a pop-up dialogue box, which consisted of five components: assigning a label or, noting of the source of content or a reference, differentiating quoted material through formatting of the text block, relating the material to a question or concept, and finally creating a summary or paraphrase.

The experimental study was conducted in 2005 and repeated in 2006 over a three-week period at Monash University involving participants from the second year of the Bachelor of Multimedia Systems program,

with participants randomly assigned to Experimental or Control Groups. The control treatment involved the processing of content using a notepad tool with the traditional form of the 'copy and paste' function while the form of the notepad tool used in the experimental treatment is depicted in Figure 2. Data collection involved video taped observations of onscreen activity, pre and post treatment surveys and the collection of participant generated notes. In order to analyse the participants onscreen activity various observed activities were equated with the level of cognitive activity required to enact them, as reported in Morgan et al. (2006b). For example creating a keyword, summary or writing independently were equated with a high level of cognitive processing of the content while activities such as browsing content were equated with a low level of cognitive processing of the content. The relative durations of activities categorised as high, medium or low were then compared between Experimental and Control Groups. In a similar way the features of texts notes produced by the participants were also categorised as being indicative of high, medium or low levels of processing, with original content being assessed as indicative of a high level of processing and unmodified copied material indicative of low levels of cognitive processing. In this case the relative volumes of text categorised as being indicative of high, medium or low processing of the content were then compared between the two groups.

The effectiveness of the experimental treatment in promoting high levels of learner processing of content has been reported in Morgan et al. (2006b). To summarise these results, differences were observed between the Experimental and Control Groups in terms of changes to interaction strategies employed by learners and changes to the features of the text produced by learners, with learners using the modified version of the 'copy and paste' function displaying higher levels of cognitive processing when interacting with the content than the Control Group.

After approximately 13 hours and 43 minutes of video taped observations were analysed, significant differences were detected in the nature and duration of participant's onscreen activity between the Experimental and Control Groups. The most significant finding was that on average the Experimental Group spent 27.65 % of their time engaged in activities that indicated a high level of cognitive processing which was a much higher percentage than the Control Group. For the Experimental Group 5.11% of their time was spent in activities that were characterised as requiring medium levels of cognitive processing of the content such as referencing. The remaining 67.25% of their time was spent in activities that required a relatively low level of cognitive processing of the content such as browsing. The Experimental Group also tended to display a greater range of activities, and also a willingness to switch between activities requiring differing levels of cognitive processing such as browsing and copying to labelling, writing and summarisation activities. It was an important finding of the study that the Control Group spent much less time engaged in activities that indicated a high level of cognitive processing and in fact only devoted 6.67% of their time on average to such activities. This pattern of low levels of engagement with the content was widespread and persistent in the Control Group who used the unmodified version of the 'copy and paste' function and tended to confirm that there was a major problem with the affordances and constraints of this tool. Only 1.63% of their time was spent in activities requiring medium levels of cognitive processing. The majority of their time, 91.70 %, was devoted to activities that required relatively low levels of cognitive processing, such as uninterrupted browsing. The Control Group tended to pursue low level processing strategies such as browsing for extended periods and rarely interrupted the browsing activity to process the content further in order to consolidate their learning by using other forms of activity that required higher levels of cognitive processing.

Statistical analysis indicated a number of significant effects were observed between the Experimental and Control Groups. Table 1 summarises the *t*-test results when comparing the average percentage of time that participants were observed to spend in activities characterised as requiring either high or medium or low levels of cognitive processing.

Table 1: Level of cognitive processing indicated by the average percentage of time spent in activities

Average percentage of time in activities indicative of the level of cognitive processing	Experimental <i>n</i> = 31	Control <i>n</i> = 28	<i>t</i> -test	<i>df</i>	Probability	Significant
High	27.65	6.67	4.7462538	57	$p < 0.001$	Yes
Medium	5.11	1.63	0.8004707	57	$p > 0.20$	No
Low	67.25	91.70	2.3860236	57	$p < 0.05$	Yes

Finally following the analysis of approximately 490 pages of notes significant differences were observed in the features of the texts produced. The texts produced by the Experimental Group over three one hour sessions contained an averaged volume of 66.79 words that indicated a high level of cognitive processing, such as writing, labels and summaries. However the Control Group averaged only 21.88 words indicative of high level processing of the content. The average volume of text that indicated moderate levels of processing, such as references, was approximately the same for both groups. The Control Group produced a larger volume of text indicating low levels of processing (777.04 words), such as unmodified copied material, than the Experimental Group (596.52 words), therefore the Control Group relied more on mechanically copying text without modification.

Table 2 summarises the *t*-test results when comparing the average volume of text features that were detected in the participants' notes and that were characterised as requiring either high or medium or low levels of cognitive processing.

Table 2: Level of cognitive processing indicated by the average volume of text features

Average volume of text features indicative of the level of cognitive processing	Experimental <i>n</i> =61	Control <i>n</i> =66	<i>t</i> -test	<i>df</i>	Probability	Significant
High	66.79	21.88	3.5089881	127	$p < 0.001$	Yes
Medium	16.36	16.13	0.4770723	127	$p > 0.20$	No
Low	596.52	777.04	2.6734777	127	$p < 0.01$	Yes

The results obtained in this initial study of the 'copy and paste' function indicated that the experimental treatment had a significant impact on the activities and output of the learners. However the embedded interaction strategy that was used may not be appropriate for all learning contexts. A range of interaction strategies may be designed in order to target different encoding strategies and in order to suit specific learning tasks.

Alternate interaction strategies for the 'copy and paste' function

The study reported here presents the implementation of one possible interaction strategy that has been embedded into the interface in one particular form. The aim of embedding the interaction strategy in the interface is to ensure that there is at least one effective interaction strategy available to all learners even if they do not possess the internal resources to implement such a strategy on their own. Alternatively the support provided by the embedded interactive strategy may allow the learner to devote more cognitive resources to processing the content for understanding. However a single interaction strategy may not be appropriate for all contexts and for all learning styles. The creation of a range of interaction strategies may benefit a wider range of learners in a wider range of contexts. If the nature of these interaction strategies were made explicit the true power of this approach may be seen when the learner can make a choice of the most appropriate interaction strategy for their particular task. The interaction strategies that will be considered include the following:

- An update of the 'note taking' strategy
- A 'categorisation' strategy
- A 'concept mapping' strategy

Redesigning interaction strategies

What would the note taking strategies then look like in this context? The following designs are now being developed to test their efficacy in developing greater user interaction with resources being used for explorations of ideas within resource rich environments such as *Exploring the Nardoo*.

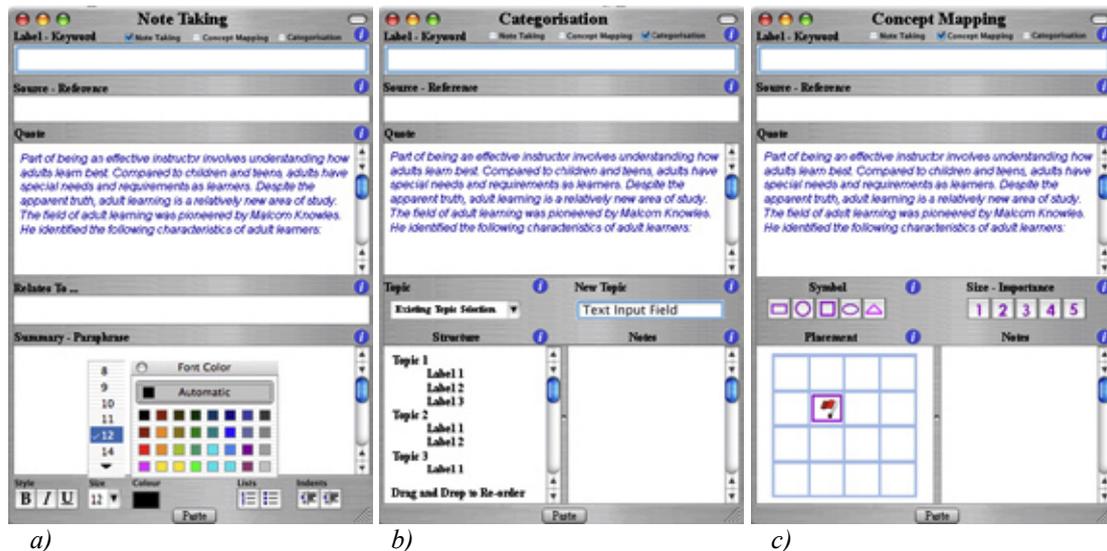


Figure 3: Interaction strategies: a) Update note taking, b) Categorisation, c) Concept mapping

Updated note taking strategy

The Note Taking strategy design depicted in Figure 3 a) has been drawn from the version used in the study reported here. The interface has been designed using the Apple interface guidelines in order to improve the design of the formatting tools in particular. The user will also have the option to change the interaction strategy selected. It is anticipated that the note taking strategy would be the default strategy for the application. The user would also be able to turn off all processing strategies and revert to the traditional form of the 'copy and paste' function via a menu option.

Categorisation

Interacting with content by 'categorising' concepts is another way to process content for understanding because it requires the learner to examine relationships and the underlying organisational structure of information. The interaction strategy of 'categorisation' could involve developing several major themes or topics and organising content within these groups. This helps emphasize the relationships between content but may also assist the learner to structure the information and their notes around several major concepts. These categories can equate to the major concepts or paragraphs used in the text. In order to implement this strategy the learner must be assisted to form a number of categories which may involve developing a detailed description of the nature of each category. The learner must also be able to assign a piece of content to a category that they have developed. The learner can also record some additional notes related to the content. When the information is pasted into the learner's notes the content should be placed into the appropriate group of content. Figure 3 b) is a screen design for the embedding of this interaction strategy into the interface.

In this strategy the learner would still need to label the content and record its source. In the 'category' area the learner could enter a new category or select an existing category from the drop down menu. In the 'structure' area the structure of categories and labels is represented. Ideally the learner should be able

to drag these about to manipulate the structure of the document at an outline level. This may also represent a 'ranking' or 'ordering' strategy and would prompt the learner to consider relationships and structure. In this case the structure would establish the order of importance of concepts.

Concept mapping

An alternate interaction strategy that could be implemented in the revised 'copy and paste' function is a 'concept mapping' strategy. This strategy represents a very effective way of encouraging learners to process content for understanding. The output of the learner using a concept mapping technique is significantly different from the raw content and reflects not only an examination of concepts but also an examination of relationships. The concept mapping technique engenders extensive processing of the content.

Constructing computer-based semantic nets engages learners in (1) the reorganization of knowledge through the explicit description of concepts and their interrelationships; (2) deep processing of knowledge, which promotes better remembering, retrieval, and the ability to apply knowledge in new situations; (3) relating new concepts to existing concepts and ideas which improves understanding [...] and (4) spatial learning through the spatial representation of concepts within an area of study (Fisher, Faletti, Paternson, Lipson, Thornton & Spring, 1990; Jonassen & Reeves, 1996, p. 707)

The interface layout required to implement a concept mapping interaction strategy could be configured in a number of ways. The interface design shown in Figure 3 c) indicates one method. In this case the learner must provide a label for the concept and also record the reference information for the source of the content. The learner must select a symbol in which the label will be placed and nominate a size for the symbol that will denote its relative importance. In the final section of the interface the learner can nominate a sector in the concept map in which the symbol will be placed and can record some additional notes related to the concept. After the learner has completed these tasks the information can be entered into a concept map using the 'Paste' button. Fine tuning of the position of the symbol and links to related concepts can then be completed on a full sized version of the concept map that would be displayed in the notes window.

Interaction strategy selection

This proposed design involves the concept of embedding a range of interaction strategies into the interface of the 'copy and paste' function. Many learners may be unaware that a variety of interaction strategies are available to process content, to take notes and to produce texts. Some may tend to rely on a single strategy due to the fact that a variety of interaction strategies have not been modelled for them. Modelling a variety of interaction strategies may encourage learners to be flexible and to enable them to deal effectively with a variety of learning situations. Asking the learner to select an interaction strategy may make learners more attentive to the interaction strategy that they are employing. This may enhance the development of metacognitive monitoring of the appropriateness of the selected interaction strategy and its results.



Figure 4: Selecting an interaction strategy

Conclusions

No single interaction strategy is appropriate for all tasks or all learners. Making available a range of interaction strategies may lead to positive learning outcomes in a wide range of learning interactions. Information on the types of interaction strategies available would be required in order to assist the learner to make a decision on the appropriate interaction strategy. From the discussions above it is clear that the interaction strategy embedded in the 'copy and paste' function in the initial study (reported in Morgan et al., 2006a, 2006b and with the major results summarised here) is only one of a variety of possible

strategies. Each strategy could be appropriate for particular contexts and would encourage the learner to process content in a different manner. Implementing a variety of interaction strategies could allow learners to work in their preferred style while still providing guidance on effective interaction strategies. This can be contrasted with the current state for the 'copy and paste' function where little guidance or support is provided to the learner and where the affordances and constraints of the cognitive tool may in fact subvert the learning objectives of the interaction. A further series of studies are now being planned around these ideas to investigate the efficacy of these tools.

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Please cite as: Morgan, M., Brickell, G. & Harper, B. (2006). The 'copy and paste' function: A flawed cognitive tool in need of redesign. In L. Markauskaite, P. Goodyear, & P. Reimann (Eds.) *Proceedings of the 23rd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education: Who's Learning? Whose Technology?* (pp. 573-582). Sydney: Sydney University Press. <https://doi.org/10.65106/apubs.2006.2943>

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