# Kanji Learning by Japanese Language Learners from Alphabetic Backgrounds: An Examination of how 'Component Analysis' Impacts Learners of Differential Proficiencies

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by

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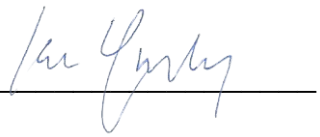
Signed:  ID No.: 16212976 Date: 09/04/2021

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**Abbreviations**

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|---|---|
| **ESL** | English as a Second Language |
| **JFL** | Japanese as a Foreign Language |
| **KUN-yomi** | Readings derived from original Japanese words. |
| **L1** | A native or first language, usually developed between birth and the age of puberty. |
| **LX** | Any language that is acquired after a first language. |
| **L1*alpha*** | A native language that has an alphabetic writing system. For example, English for a native reader. |
| **L1*morph*** | A native language that has a morphographic writing system. For example, Japanese for a native reader. |
| **L1*logo*** | A native language that has a logographic writing system. For example, Chinese for a native reader. |
| **ON-yomi** | Readings derived from Chinese words |
| **Reading** | Pronunciations of kanji characters that originally derive from either Japanese (KUN) or Chinese (ON)**.** |
| **SLA** | Second Language Acquisition |

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Finally, I dedicate this to Leon and Sean, my inspiration.

**Title**

Kanji Learning by Japanese Language Learners from Alphabetic Backgrounds:
An Examination of how 'Component Analysis' Impacts Learners of Differential Proficiencies

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**Abstract**

One aspect of Japanese that continues to challenge learners is the idiosyncratic writing system, a complex orthography consisting of two phonetic syllabaries and thousands of morphophonemic 'kanji' characters. The perceived difficulty of kanji can affect student motivation (Mori & Shimizu, 2007) and can be responsible for higher attrition rates among students who are not familiar with morphographic writing systems (Grainger, 2005). Experimental data on kanji processing models suggests that L1 learning methodologies could be a potentially valuable reference for LX pedagogical research. Studies on cross-linguistic transfer provide evidence that LX decoding efficiency can be impacted negatively among learners with incongruent L1 orthographic backgrounds (Hamada & Koda, 2008, p. 23), suggesting that alphabetic learners may have particular difficulty with kanji. One recommended pedagogical response is to employ a 'component analysis' learning strategy that targets awareness on the individual components within kanji characters (Chikamatsu, 2005; Hagiwara, 2016), allowing learners to more efficiently extract semantic and phonological information from the characters. This study tests the recommendation by (1) designing and implementing teaching materials that enact component analysis in a real classroom situation, (2) monitoring changes in kanji processing by alphabetic learners of differential proficiencies, and (3) analysing the nature and possible causes of any changes observed.

Implementing the strategy over a 12-week semester, data indicates that a group of ab-initio learners developed more efficient responses in kanji decomposition than a group of lower-intermediate learners with prior kanji learning experience. The finding is interpreted as evidence that using component analysis could facilitate compositional awareness in beginners, despite having a limited lexicon, while learners with prior kanji knowledge may experience some difficulty adjusting to this unfamiliar strategy. Feedback responses indicate that the success of component analysis may be contingent upon factors such as workload, enjoyment, and perceived effectiveness of specific tasks in the prescribed exercises.

# 1 Introduction

## 1.1 Context of this study

This study is originally motivated by direct observations made while teaching Japanese as a Foreign Language (JFL) over the course of approximately seven years in universities and schools. During that time, there were several recurring themes highlighted by students who were having difficulty with the various challenges of learning Japanese. One of those themes was the students' apparent frustration when contending with the complexity of the Japanese writing system. While there are many different skills involved in acquiring proficiency in Japanese, the students often pointed to the writing system as a stumbling block that they found to be a particularly difficult challenge. Full literacy for L1 readers requires knowledge of over 2000 'kanji' characters, according to guidelines published by the Japanese Ministry of Education (2010). While a basic functional literacy for learners may be possible with a lower number of kanji, it is nonetheless a daunting task for a student who has just begun the learning process. The difficulties that students seem to face may be compounded by perceived challenges that language teachers themselves face. For example, while there are many different approaches to teaching kanji, it seems difficult for some teachers to recognize which strategies might be the most effective and why. Teachers can choose from a variety of strategies such as rote writing, the use of mnemonics, emphasis on components, contextual approaches, or hybrids of these and other learning strategies. For a teacher, the range of possibilities might be perceived as a challenge since the rationale for choosing one approach over another may be based solely on personal experience or on anecdotal evidence, making the decision seem and feel somewhat arbitrary. This is especially important in light of evidence that teachers' attitudes towards kanji might play a significant role in their own teaching. In a study exploring teachers' attitudes towards kanji, Shimizu and Green (2002) found that "the teachers who believe that teaching kanji is difficult tend to believe that students do not enjoy learning kanji, and these teachers are not likely to enjoy teaching kanji either" (2002, p. 239). The role of a teacher includes the responsibility to guide students toward resources and strategies that will maximize their effectiveness in terms of achieving their learning goals. However, if a teacher lacks information or understanding of the available strategies or resources, they may not be able to

make a sufficiently informed recommendation. This, in turn, could lead to a situation in which students are faced with the intimidating task of learning thousands of complex characters but without an adequate plan in place to form the foundation for this undertaking. It is vital that the validity of the available learning strategies is tested accordingly, from their underlying assumptions to their intended effects and practical feasibility. This study, therefore, is motivated by the need for JFL teachers to be able to implement or recommend an approach to teaching or learning kanji that is supported by empirical evidence from real classrooms rather than being based on anecdotal strategies or personal preference. The purpose is not to detract from how JFL teachers currently conduct their instruction since personal preference can be a valuable intuitive tool for any teacher. Rather, the goal is to provide teachers (and learners) with information that can inform their decisions about selecting learning strategies that contribute effectively to their proficiency goals related to the Japanese writing system.

## 1.2 Aim of this study

The aim of this study is to critically examine one specific kanji learning strategy in a natural learning environment. The examination seeks to test the validity of the strategy by measuring whether it actually produces its stated outcomes and, if it does, to understand properly the process that led to those outcomes. To achieve the aim, this study selects one kanji learning strategy and analyses the observed effects in learners using that strategy in a real classroom situation over the course of a semester. The analysis includes an investigation of a range of factors that could possibly impact the successful design and implementation of materials that enact that strategy. By providing a detailed analysis of one kanji learning strategy, this study can be used as a reference point for further research that focuses on establishing the validity of various kanji learning strategies. Ultimately, it is hoped that this study will contribute to a body of research that enables JFL teachers to make more informed and justifiable decisions regarding which kanji learning strategies to use in the classroom or to recommend to their students.

Having completed a review of the literature on kanji processing and learning, a 'component analysis' learning strategy was selected as being the most appropriate target of a more detailed examination. To achieve the stated aim, this study was carried out in two phases. The first phase consisted of three stages of qualitative data collection. The data was collected from JFL teachers, from JFL source materials, and from classroom observation sessions in the domestic Japanese education system. Analysis of these data sets informed the design of component analysis teaching materials. These materials were then used in the second phase of the study, which consisted of a further three stages of data collection. In this phase, an analysis of eye-tracking data was integrated with an analysis of kanji writing errors in a mixed methods approach. A post-semester student feedback survey was also conducted.

## 1.3 Structure of this study

The body of this thesis contains nine chapters. Following this introductory chapter, Chapter 2 begins with a brief summary of the evolution of the Japanese orthography, included because it has relevance to some areas of kanji pedagogy. The core of Chapter 2 is a review of kanji learning strategies and literature that deals with kanji processing and learning. The review focuses on studies relating to L1 kanji processing and the critical issues that impact LX learners of kanji[1]. Chapter 3 presents the research design and the methodological considerations involved in the study. This is followed by a description of the overall methodological approach, consisting of two phases. Chapter 4 details the methodology of the first phase, PHASE 1, during which three sets of data were collected. These were data from a survey of JFL teachers, an analysis of JFL textbooks, and field notes from classroom observation sessions carried out in the domestic Japanese education system. Chapter 5 presents the findings of the first phase and a discussion of how the findings inform the second phase of the study. Chapter 6 presents the methodology of PHASE 2, beginning

[1] The term 'LX', proposed by Dewaele (2018), is intended as a more accurate replacement for the terms 'L2' or 'non-native language', which are commonly used in the literature. For the purposes of this thesis, when using direct citations, the original 'L2' terminology is retained. All other instances use the term LX.

with a detailed description of the design of the teaching materials used in this phase. A further three sets of data were collected during this phase. To monitor and understand changes in kanji processing of the participants, eye-tracking data and kanji writing error samples were collected. The final stage of this phase was a student feedback survey, the purpose of which was to understand practical issues highlighted by the learners who actually used the materials. Chapter 7 presents the findings from the second phase of the study. This is followed in Chapter 8 by a discussion of those findings and how they address the research questions. Finally, Chapter 9 offers a summary of conclusions from both phases of the study. Chapter 9 also includes a brief discussion of possible contributions to theoretical models of LX kanji pedagogy, some limitations of this study, how the findings may have implications for kanji learning in the classroom or for learners who are engaged in self-study, and some recommendations for further areas of study.

# 2 Literature Review

## 2.1 Introduction

The aim of this study is to test the validity of a specific LX kanji learning strategy in the context of a real classroom situation. The investigation will focus on how the strategy can be correctly implemented and whether it actually delivers on its stated aims in the learning process. This chapter contains a review of several areas which relate to the features of kanji itself and kanji learning. The purpose of this review is to help identify a specific LX kanji learning strategy that appears to have potential but which does not yet have sufficient empirical support in the context of authentic classroom situations. Such a detailed examination, it is hoped, will provide an understanding of its underlying validity as an LX pedagogical strategy. In order to identify one particular learning strategy as the subject of further examination, it is first necessary to understand what kind of factors converge to produce a kanji learning strategy in the first place. The large number of kanji on the basic literacy lists, in tandem with their visual and morphological complexity, means that research on kanji learning can involve a wide range of topics, including memory (Chikamatsu, 2005), cognition (Sakuma, Sasanuma, Tatsumi, & Masaki, 1998), motivation (Kondo-Brown, 2006; Nesbitt & Müller, 2016), learner autonomy and self-regulation (Rose & Harbon, 2013), and pedagogical issues faced by teachers and learners alike (Dewey, 2004; Everson, 2011; Mori & Shimizu, 2007). With such a wide range of possible fields from which to draw, the review in this study focused only on a critical review of literature on L1 kanji processing, issues in LX kanji learning, and some additional factors that may impact both. In short, the purpose of this chapter is to draw on both L1 and LX literature to identify a candidate LX kanji learning strategy that shows genuine effectual potential but has not yet been subjected to sufficient empirical analysis to understand its benefits fully in actual classroom situations.

Section 2.2 provides an overview of the Japanese writing system and a brief account of how kanji were imported into the Japanese language. This is relevant since the topic of kanji composition plays a meaningful role in several aspects of this study. Section 2.3 presents an overview of typical

kanji learning strategies that feature in mainstream JFL publications. Section 2.4 contains a detailed review of studies on L1 cognitive processing mechanisms in kanji, neurological cases that provide insights into kanji processing, and studies that explore whether there is an anatomical basis for observed qualitative differences in L1 kanji processing. This section includes an examination of research that considers other factors in kanji processing, such as how print-to-sound consistency and lexical frequency can impact processing. Section 2.5 proceeds with an examination of aspects of kanji learning that are relevant to LX learners. Processing differences between L1 and LX kanji users are discussed, and studies that examine orthographic transparency and cross-linguistic transfer are presented, with a summary of the possible pedagogical implications of the findings from those studies. Section 2.6 discusses why 'component analysis' is the most suitable kanji learning strategy for a more detailed examination based on the review above. Section 2.7 presents the primary and secondary research questions of this study. Finally, Section 2.8 concludes with a summary of all of the above.

## 2.2 The Japanese writing system

Up until the fifth century, approximately, Japanese was a predominantly oral language and did not have a well-developed orthography of its own (K. Hatasa, 1989; Seeley, 1984; Taylor, 1995). With the introduction of borrowed Chinese characters (called 'kanji'), scholars of the time attempted to map these imported characters onto an already-existing Japanese morphology and phonology. As the Chinese language and its pronunciations changed over time, Japanese continued to borrow these new readings while simultaneously retaining the older readings. Waves of borrowing from Chinese over consecutive dynasties had the effect of "introducing new, competing pronunciation norms and readings of texts" into Japanese (Frellesvig, 2010, p. 275). The unique way in which the characters were imported from Chinese into Japanese has resulted in an irregular and idiosyncratic character-to-sound mapping in kanji, wherein the relationship between semantic components and phonetic components is not always straightforward. In fact, many kanji characters have been

assigned multiple possible pronunciations. Over time, difficulties in reading kanji resulted in the gradual evolution of two additional 'kana' syllabaries[2]. These syllabaries are called 'hiragana' and 'katakana.' Both are orthographically derived from kanji but have a much simpler appearance. Hiragana and katakana are phonetic characters, whereas kanji are morphographic[3]. Modern Japanese has retained the integration of kanji and kana in all standard forms of writing. In Japan, kanji literacy is prescribed in a standardised list of 2136 characters, called 'Joyo Kanji' (Ministry of Education - Japan, 2010). Each kana syllabary has a total of 71 characters (basic characters, characters with diacritics, and half-sized characters) and represents around 100 phonemes (K. Hatasa, 1989, p. 8). See Figure 1 below for a visual overview of the three types of script, generated in MS Excel for the purposes of showing compositional differences.

| Hiragana | Katakana | Kanji |
|---|---|---|
| あ | ア | 亜 |
| い | イ | 意 |
| う | ウ | 宇 |
| え | エ | 絵 |
| お | オ | 緒 |

*Figure 1: Japanese scripts Hiragana, Katakana, and Kanji*

Kanji themselves can be divided into several different categories, as discussed below in Section 2.2.1. One aspect of importance in kanji is the existence of components[4] in a large number of characters. For example, many kanji are composed of a dominant 'radical' component together with one or more additional components. Radicals are "a set of smaller elements, corresponding to semantic categories, into which characters in Chinese writing are analysed ... and classified" (Matthews, 2007, p. 332). Radicals are useful to lexicographers as an indexing system, but the

[2] A syllabary is a system "whereby sound maps onto the printed symbol at the syllable level" (Everson, 2011, p. 252).
[3] The term 'morphographic' is used to refer to individual graphemes that represent complete grammatical morphemes, as kanji do (Twomey et al., 2013, p. 184).
[4] The terms 'component' and 'subcomponent' are sometimes used interchangeably in kanji literature. Both terms describe the functional sub-character units in kanji that carry semantic and/or phonological information (Toyoda, Arief, & Kano, 2013, p. 235). This study uses the term 'component' to refer to all these sub-character units, unless otherwise stated.

existence of components also has significant implications for cognitive processing. For example, when testing the possible effects that semantic radicals have on the reading of kanji words, Miwa et al. (2012) found that “semantic radicals emerge as not just orthographic components but as fully fledged purely orthographic morphemes” (2012, p. 142). The authors propose a processing model that explicitly points to individual kanji components as playing a vital role in the processing of whole words or compounds (Miwa et al., 2014, p. 203). While radicals often contain important semantic information, other components can also provide semantic information, or phonetic information, or both. For example, the character 月 is used as a radical component in dozens of kanji characters. One of the meanings of the component is 'flesh', and it features in many kanji that have a semantic connection to the human body. Examples are 膝 (knee), 腕 (arm), 腸 (intestines), and 肌 (skin). Each of these kanji contains the same 'flesh' radical positioned on the left, denoting them as a subgroup of words that relate to the body. Phonetic information can sometimes be provided by other components, such as in the example 肌 (skin) from the list above, where the 'flesh' radical contains semantic information while the other element on the right, 几 (table), contains phonetic information. The presence of this element in a kanji character indicates that one likely reading (pronunciation) of the word is '*ki*'. In fact, one of the readings of 肌 (skin) is indeed '*ki*'. Other kanji that include this phonetic component are 机 (desk), 飢 (starve), and 毅 (strong). All these characters share the common pronunciation '*ki*' as one of their readings.

While the positioning of a component can be a general indication of its role in providing certain types of information, there are no strict rules governing this. For example, the character 多 (many) appears in several compound words, such as 多数 (large number), where it is read as ‘ta'. However, when it appears as a component in another character such as 移 (move), the character is not read as ‘ta', but as ‘i'. Another example of this inconsistency is the phonetic component 昜 (‘glorious’). This component appears in the right side of the kanji 陽 (‘sun’) and provides a reading of ‘yō’ to the character. However, the same component also appears in the kanji 腸 (‘intestines’), but this character is read as ‘chō’. In fact, there are many cases like this, where the reading of a particular

character cannot be inferred simply from determining what the composition of the components is. The implications of this are discussed in more detail in subsequent sections.

### 2.2.1 Kanji classification

Standard models of categorization subsume all the Japanese kanji into four[5] distinct types (Hiraga, 2006, p. 135). These are[6] (1) pictograms, where a character is a direct pictorial representation of a physical object. Examples are 川 (river) and 山 (mountain); (2) simple ideograms, in which abstract ideas are represented in an uncomplicated visual form. Examples are 三 (three) and 上 (up); (3) compound ideograms, wherein two or more components are combined to communicate the semantic relationship between them. Examples are 囚 (criminal – the components representing a person in an enclosure) and 安 (rest – representing a woman under a roof); and (4) phonetic characters, containing a component that provides information on possible character pronunciations. These may also contain an ideographic component. Examples of phonetic characters are 汁 (soup) and 壮 (prosperous), where the right-positioned components contribute a pronunciation to the entire character. Of the four main categories listed above, phonetic characters (Category 4) comprise the largest group, with as much as 60% of Japanese kanji falling into this category (Miyashita, 2004).

In summary, the core of the Japanese writing system consists of a large number of kanji (borrowed Chinese characters) combined with two smaller phonetic syllabaries (hiragana and katakana). Kanji themselves have four main categories and are more complex than kana in terms of their composition, morphology, semantics, and phonology. Many kanji have components that contain

[5] A further two categories were proposed in the "Rikusho Bunrui", first introduced by Kyoshin, a Chinese scholar (Atsuji, 1988). This system includes the additional categories of (5) loan kanji (*kashaku-moji)*, wherein a character's original sound was preserved, but not its meaning, and (6) analogous kanji (*tenchū-moji)* which are "new kanji patterned after old kanji to denote new meanings (Tamaoka et al., 2002, p. 262). However, this six-category system may be more suited to Chinese, which contains several thousand more characters than Japanese. For example, there are no analogous kanji (Category 6) in the standard list of kanji required for basic literacy (Tamaoka et al., 2002, p. 262). This study uses the main four-category system in references.

[6] All examples are from "A Web-accessible database of characteristics of the 1,945 basic Japanese kanji" (K Tamaoka et al., 2002).

semantic and phonological information. However, the evolution of the orthography has resulted in inconsistencies in character-to-sound correspondences, producing a complex system wherein it is not always apparent what the standard reading of a given kanji might be.

## 2.3 Kanji learning strategies

The topic of second language acquisition and language learning is by nature wide-ranging, with a number of competing hypotheses that attempt to explain the processes involved. As noted by Ellis (1997), "there is no single theory or model or even framework that can adequately incorporate the range of hypotheses which SLA has addressed" (1997, p. 89). Within that broad field is the category of actions that learners themselves can take to steer their own learning process towards their goals. Rose (2017) defines these language learner strategies as "processes and actions that are consciously deployed by language learners to help them to learn or use a language more effectively" (2017, p. 38). In terms of kanji learning strategies, while there are a variety of possible approaches, they can be categorized into broad groups that generally share similar themes. Rose (2017) proposes a framework that divides these into a behavioural perspective (self-regulation, motivation, affective factors) and a cognitive perspective (mnemonics, the use of visual association, decomposition techniques). This review concentrates primarily on the cognitive perspective.

Cognitive strategies (association, mnemonics, decomposition, etc.) often involve some kind of deliberate attempt by the learner to use an artificial technique that aids memory and furthers the learning process. With association techniques, aspects or properties of the characters, such as their shapes, meanings, etymologies, etc., are attached to meaningful information for the learner in an attempt to memorize and subsequently recall the character more easily. This features in a range of established Japanese textbooks that target kanji learners, such as the 'Basic Kanji' series (Chieko et al., 1989; Kano et al., 1989), which contains numerous references to semantic kanji etymologies

and links these to simplified images of pictographic kanji or ideographic components. Mnemonic strategies can have somewhat broader definitions but generally "make use of association, organization, elaboration, and imagination in order to facilitate encoding, which, in turn, affects both storage and retrieval" (Esposito, 2016, p. 107). For kanji learning, a typical example is 'Remembering the Kanji' (Heisig, 2007), whereby pre-defined keywords are arbitrarily assigned to kanji components (called 'primitives' in the system), and detailed user-generated narratives are then used to construct memorable stories which, it is claimed, will aid in recalling the characters. This type of approach is included as a dominant feature of several other kanji learning textbooks (e.g. Henshall, 1988; Rowley, 1992). Other textbooks such as 'The Kanji Learner's Course' (Scott Conning, 2013) include such mnemonic techniques but make use of a variety of other techniques like association, decomposition, etc.

Rote writing is another possible approach and seems to be common in both L1 and LX learning. Shimizu and Green (2002) observe that "rote writing and drills used to be conventional strategies in Japan and still seem to be widely used in teaching kanji" (2002, p. 230). The same study found that rote learning was still the most common strategy of teaching kanji among JFL teachers (2002, p. 227). There is evidence that LX learners respond well to rote-learning techniques. For example, Nesbitt (2009) tested rote-learning techniques on twenty beginner-level LX kanji learners, with the stated goal of "achieving unconscious recall of kanji" (2009, p. 61). He found that students benefited most from rote-writing techniques, concluding that a particular rote-writing technique he used "was clearly perceived to meet most learners' needs, as well as being the most beneficial" (2009, p. 70). Yamashita and Hung (2016) found that, among learners who had some previous experience learning kanji, a range of strategies was used but that "rote-repetition was the one used by the most participants" (2016, p. 142). Rote writing exercises are a core feature in many kanji learning workbooks, wherein the learner is provided with a grid of practice boxes and a reference model character (usually in cursive font). The task is to refer to the model character and reproduce it by repeatedly writing the character in the available space on the grid. For example, Basic Kanji Volume 1 (Kano et al., 1989) begins each chapter with this exercise. A recent study, although not

related specifically to kanji learning, offers corroboration of the importance of recruiting motor skills when writing, with possible implications for language pedagogy. Umejima et al. (2021) compared the memory retrieval of Japanese participants who took written notes under the three experimental conditions of (1) using a pen and paper, (2) using an electronic tablet, and (3) using a smartphone. They found that memory retrieval was far better when participants used a pen and paper, stating that "our present experiments demonstrated that brain activations related to memory, visual imagery, and language during the retrieval of specific information, as well as the deeper encoding of that information, were stronger in participants using a paper notebook than in those using electronic devices" (2021, p9). The authors caution against abandoning methods such as writing with paper, suggesting that further research is needed that can explore how e-learning can be optimally integrated into these traditional methods rather than superseding them.

Other strategies place emphasis on the importance of reading kanji in context rather than focussing on learning readings in isolation. This kind of approach assumes that exposure to the target language in a natural context will aid the learner in developing reading proficiency. Such an approach has some support in the literature. For example, Mori (2002) examined whether L1$^{alpha}$ learners[7] of Japanese benefited more from using kanji morphology clues (intrinsic information such as character meaning) or from using contextual information (compound words in sentences) when trying to infer the meaning of unfamiliar kanji words. By testing learners' performance in tests under the three conditions 'kanji only', 'context only' and 'both kanji and context', it was found that learners had significantly higher accuracy in the 'both kanji and context' experimental condition (Mori, 2002, p. 387). The textbook and workbook series 'Kanji in Context' (Nishiguchi & Tamaki, 1996) is a typical example of this contextual approach.

[7] The term L1$^{alpha}$ is used in this thesis to refer to any native language that has an alphabetic writing system. In the context of Japanese learners, a typical example of an L1$^{alpha}$ learner is a person who is learning Japanese but whose native language is English.

There are a number of other possible approaches. One interesting option is to use a variation of finger-tracing called 'kusho'[8] (Itaguchi et al., 2017; Sasaki & Watanabe, 1983), meaning 'writing in the air' or 'air-writing'. There is evidence that tracing kanji characters with one's finger can aid kanji learning by strengthening the visual representations of kanji in long-term memory. For example, Itaguchi et al. (2017) performed experiments that tested L1$^{morph}$ [9] students' kanji performance under specific conditions, with one of the conditions involving the use of kusho. In tasks that involved reconstructing kanji from component parts and testing reaction times under the different conditions, it was found that "executing kusho behavior during the cognitive task improved performance regardless of memory demands as long as the participants watched their finger movements. This result supports the idea that visual feedback of kusho behavior helps in solving cognitive tasks" (Itaguchi et al., 2017, p. 8). This technique appears to have ready transferability to the LX classroom. Thomas (2015) also tested the performance of learners using kusho, but with LX learners. In her experiments, learners were required to memorize kanji characters under three different conditions, with kusho being one of the conditions. She found that "kusho is associated with a small but statistically significant advantage in accuracy of recall, compared to either passive visual inspection or the conventional technique of memorizing the shapes of kanji by iterative paper-and-pen copying" (2015, p. 631). Studies such as these suggest that techniques like air-writing could be integrated into LX kanji learning materials with possible benefits to learners.

Decomposition strategies such as 'component analysis' involve "the act of breaking down kanji into its components (or graphemes) to assist in memorization" (Rose, 2017, p. 60). This strategy places emphasis on the importance of perceiving a kanji character as an assembly of its constituent components rather than as one single unit. Using such a strategy, the discrete elements or components in characters are seen as individual building blocks that can be recognized when they

[8] The Japanese word is 空書 (くうしょ) (Murakami, 1991), meaning 'air writing'. This word is transliterated variously as 'kusho', 'kuusho', 'kusyō', etc., depending on which system of romanization is used by an author. The term 'kusho' is used here unless contained within a direct citation.
[9] The term L1$^{morph}$ is used in this thesis to refer to any native language that has a morphographic writing system. A typical example of an L1$^{morph}$ reader is a native reader of the Japanese language.

recur in unfamiliar material. The strategy aims to make kanji learning more manageable by enabling learners to perceive characters as collections of recognisable patterns rather than random collections of individual strokes. Systems that use this strategy tend to emphasize memorizing high-frequency individual components early in the learning process. The rationale in doing so is that subsequently encountered new kanji can be more easily recognized as a collection of already-known components rather than a completely new character. An example is 'Let's Learn Kanji: An Introduction to Radicals, Components and 250 Very Basic Kanji' (Mitamura & Mitamura, 1997), which introduces the learner to high-frequency components that recur in many common kanji characters.

Furthermore, there is evidence that this could be an effective tool for some LX learners. For example, Aneros et al. (2020) used '*naritachi*' (a type of component analysis) to teach kanji to intermediate LX learners and tested recall of the target kanji before and after the experimental intervention. They report a significant increase in the successful memorization of target kanji characters using a *naritachi* strategy and conclude that it could have tangible benefits for intermediate-level learners (Aneros et al., 2020, p. 285). There may even be target language-specific benefits for LX learners. Uni (2019) points out similarities between how Malay and Japanese can be processed, noting that "a Malay root … and its derivatives have a semantic scope similar to that of Japanese words that include a common semantic component" (Uni, 2019, p. 129). In his experiments on L1 Malay readers, he used an explicit focus on components to teach kanji vocabulary and found that it produced higher rates of recognition than found in control groups (Uni, 2019, p. 140). One possible drawback to this strategy is that it might create difficulties for those with a limited lexicon, such as beginners (Rose, 2017, p. 65).

One aspect of decomposition strategies that may be significant is that the compositional features of kanji may influence the cognitive processing of the characters in readers. Studies such as Toyoda (2009) and Hatta et al. (1998) highlight the key role that individual components might play in

processing by LX kanji readers. Toyoda tested how accurately $L1^{alpha}$ kanji learners could distinguish components and concluded that "learners are better at using semantic information than using phonological information for processing kanji words" (Toyoda, 2000, p. 1). Hatta et al. (1998) point out that errors made when writing kanji are evidence of faulty representations of the characters in long-term memory and that “the analysis of kanji writing errors must be a promising way to study the cognitive processing of kanji” (1998, p. 458). Likewise, studies on $L1^{morph}$ cognitive processing of kanji have demonstrated the importance of compositional awareness in proficient kanji reading (e.g. Higuchi et al., 2015; Miwa et al., 2012; Saito, Masuda, & Kawakami, 1999). Both L1 and LX readers appear to share a sensitivity to compositional features such as individual components, introducing the possibility that a common processing model might be able to account for variations manifested in readers from the different groups. The likelihood that LX kanji learners experience interference from their L1 orthographic background must also be considered and is discussed in more detail in Section 2.5 below. Other aspects of kanji reading, such as determining the correct pronunciation of a kanji word, have been seen to share some of the cognitive processes involved in reading English exception words, such as whole-word processing and use of context (Otsuka & Murai, 2020, p. 1). Given that some aspects of kanji learning may be common to L1 and LX readers, the possibility of the transferability of effective strategies from L1 to LX should also be explored in detail. In specific, there is a large body of research on L1 kanji cognition that could have potential as a resource in the study of LX kanji learning strategies. Therefore, before moving to the issue of LX kanji learning in more detail, a concise review of L1 kanji processing is warranted.

## 2.4 Kanji processing

### 2.4.1 Introduction

This section contains an overview of research on the processing of kanji by $L1^{morph}$ readers. In comparison to LX, kanji processing has been researched far more extensively in the L1 context.

Understanding L1 processing in detail can be useful for research into kanji processing by LX learners since it provides a comparative reference for efficient kanji reading and can be used to examine whether findings from L1 literature can be appropriately applied to the LX learner and, if so, how best to proceed. Furthermore, identifying commonalities in the groups can allow conclusions on the effectiveness of LX kanji learning strategies to be justifiably extracted from L1 cognitive processing research.

Section 2.4.2 outlines the prevailing models of kanji processing (M. Coltheart et al., 1993; Verdonschot et al., 2010) and discusses their features in light of the most recent findings on the issue. Section 2.4.3 explores whether there is an anatomical basis for the dual-route processing model of kanji. It provides a review of empirical studies that have used kanji as a stimulus in experiments from the neurological perspective. Section 2.4.4. examines studies that focus on factors that have been shown to have a measurable impact on the processing of kanji characters, such as lexical frequency and print-to-sound consistency (Kayamoto, Yamada, & Takashima, 1998; Wydell, Butterworth, & Patterson, 1995). Section 2.4.5. examines kanji compositional features such as radicals (K Tamaoka & Yamada, 2000) and visual complexity (K. Tamaoka & Takahashi, 1999) and how they might influence kanji processing. Finally, Section 2.4.6 presents a summary of the key findings from the review of literature on L1 kanji processing.

### 2.4.2 Processing models

From the mid-1970s onwards, methodologies from studies using alphabetic characters began to be used as a basis for analogous research on the Japanese language. Some of these studies on alphabetic characters are notable because they tested print-to-sound correspondences and were subsequently used as references in research on print-to-sound correspondences in kanji, shaping some assumptions about how kanji are processed. For example, Baron and Hodge (1978) conducted experiments that measured subject responses to artificial alphabets with varying degrees of print-to-sound consistency. Using subjects' responses to nonsense words under the different

consistency conditions, they found that “even though subjects did not notice the existence of correspondences, they were able to decode new nonsense words in the same alphabet” (Baron & Hodge, 1978, p. 55), suggesting clear processing advantages under regular grapheme-to-phoneme correspondence conditions. Because of its regular phonemic correspondences, kana characters (hiragana and katakana) were used in experiments as an analogous Japanese counterpart to regular alphabetic scripts. For example, Feldman (1980) conducted similar experiments on grapheme-to-phoneme correspondence, using kana instead of ‘regular’ alphabets and kanji instead of ‘irregular’ alphabets as stimuli. Feldman found “a significant facilitation of vocalization for the sound-referencing kana orthography relative to the logographic kanji orthography” (1980, p. 145), suggesting a processing advantage in regular grapheme-to-phoneme conditions, as was seen in the Baron and Hodge alphabetic experiments. Similarly, Kimura (1984) tested how vocal interference would impact semantic categorization tests and found that “concurrent vocal interference impaired the reading of kana but did not affect the reading of kanji” (1984, p. 117), suggesting that phonological influence played only a minor or insignificant role in initial kanji processing. While these findings seemed to indicate that kanji were processed semantically, it does not amount to clear evidence that kanji are processed *primarily* semantically and that phonological factors are not relevant. Potentially confounding variables such as visual complexity, character frequency or the possible influence of homophony had not yet been allowed for in the methodologies.

Van Orden’s (1987) experiments on homophony became an important methodological reference in understanding whether the Baron and Hodges conclusions could be justifiably applied to Japanese. Van Orden tested whether readers of English are susceptible to the effects of homophony by using semantic category judgement tasks. A category (such as flowers) was first introduced. The participants were then shown a word (such as ‘rose’) and asked to judge whether the word belonged to the stated category or not. It was found that pairs of homophonic words (such as ‘rows' and ‘rose') had significantly higher error rates than their non-homophonic counterparts. Van Orden concluded that phonological influence was directly responsible for the high error rates (1987, p. 192). Wydell et al. (1993) applied this methodology to kanji and examined whether homophony

effects would be observed in readers of kanji who were presented with the same kind of semantic categorization tasks. If kanji are mainly processed semantically with minimal influence from phonological features in the characters, the null hypothesis would predict that homophony effects should be negligible or non-existent. However, the experiments provided evidence that words that were homophonic foils produced higher error rates and longer reaction times than non-homophonic words and control words, just as in the Van Orden experiments. These findings were "contrary to the common belief that access to phonology from kanji must be mediated by orthographic access to the semantic system… and provide strong evidence for direct (nonsemantic) access to phonology from kanji words" (Wydell et al., 1993, p. 502). The overall conclusion was that "both phonological and visual components play an important role in category judgements for kanji" (Wydell et al., 1993, p. 502). This was particularly significant as it provided evidence that phonology might play a more active role in kanji processing than was previously thought.

#### 2.4.2.1 Single-route models vs dual-route models

At the time of Wydell's study, processing models of reading printed words generally fell into the category of 'single-route' models and 'dual-route' models. Single-route models such as the Parallel Distributed Processing (PDP) model (Seidenberg & McClelland, 1989) proposed "a single, uniform procedure for computing a phonological representation from an orthographic representation (1989, p. 525). In dual-route processing models such as the Dual-Route Cascaded (DRC) model (Coltheart et al., 1993), "skilled readers have at their disposal two different procedures for converting print to speech" (1993, p. 589); a lexical route and a sub-lexical route. The lexical route describes a process in which the reader, when visually presented with a printed word, first accesses the corresponding item in their lexicon by means of semantic mediation, thus allowing for the subsequent naming of the word. The sub-lexical route involves the construction of a word's phonology by reliance on print-sound correspondences, without the need to access the lexicon prior to naming the word. Figure 2 below shows a representation of a dual-route processing model for alphabetic scripts, based on the Coltheart (1993) processing mechanism described above.

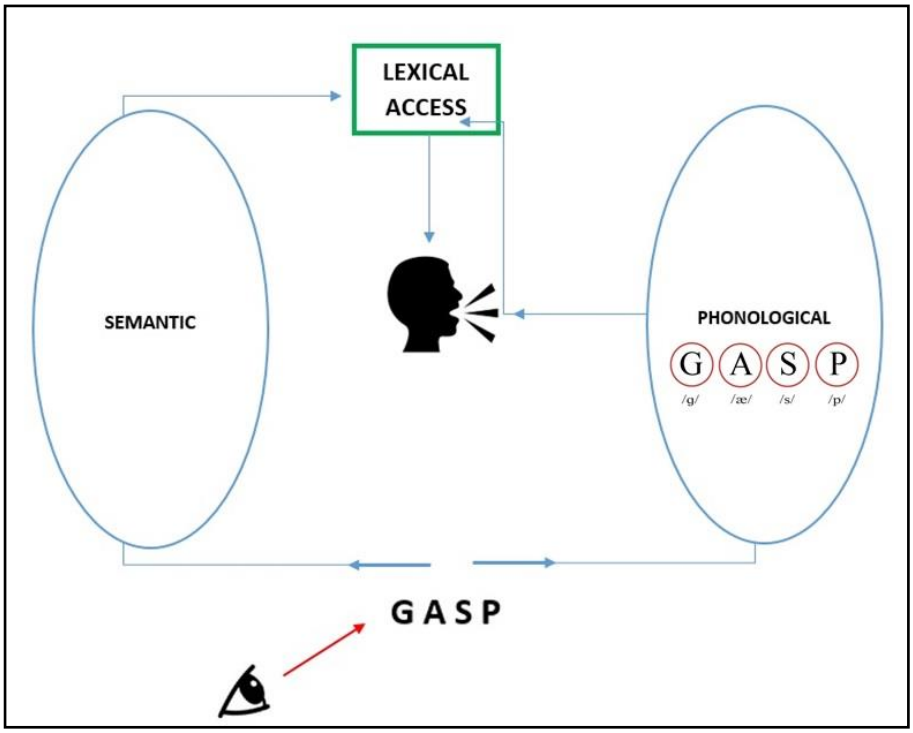



*Figure 2: Representation of a dual-route processing model*

The sub-lexical route is sometimes further refined to comprise two discrete processing paths (Verdonschot et al., 2010, p. 512). In one of these sub-lexical routes, processing functions by explicitly mapping graphemes to phonemes. Words are named by assembling the individual phonemes and vocalizing them in sequence. In the other sub-lexical route, a given word is processed by first accessing the phonology of the word through its word-form representation taken as a whole or in segments. Rather than constructing the phonology by assembling the individual phonemes in sequence, the word-form itself is the source of its phonological information. To provide an example from English, Roelofs et al. (1996, p. 248) explain this with the word "cat". When printed and presented to readers, in one sub-lexical route the phonemes /k/, /æ/, and /t/ are assembled in sequence prior to lexical access, and the word is thus vocalized. In another sub-lexical route, the phonological form of /kæt/ is taken as a whole, thereby allowing the word to be vocalized. In contrast, with a lexical route, a word's orthography directly triggers its lexical representation. Lexical access then allows for the correct identification of the word's phonology and subsequent vocalization. Using the same example, the orthographic representation 'cat' triggers semantic access to the concept of a cat. Having identified the lexical item, the corresponding phonology is generated and subsequently vocalized.

Using the assumptions contained in the dual-route model of processing for alphabetic languages described above, the question of how kanji are vocalized by readers began to be explored in more detail. Attempting to clarify how the phonology of kanji are constructed in word-naming tasks, Fushimi et al. (1999) conducted tests that sought to compare processing at the whole-word and sub-word levels. Using the criterion of the frequency of the readings (pronunciations) of kanji characters, it was found that atypical readings resulted in less efficient processing (Fushimi et al., 1999, p. 382). For example, when participants were asked to vocalize words from six different categories, words with consistent readings registered a far higher accuracy than words with inconsistent readings (1999, p. 386). The significance of these consistency effects led the authors to conclude that "phonology is computed from knowledge of print-sound correspondences at both whole-word level and sub-word level" (Fushimi et al., 1999, p. 398), pointing to the existence of multiple processing routes. In another recreation of Van Orden's (1987) naming task experiments, homophonic foils were shown to have significant effects on $L1^{morph}$ kanji processing, even when explicit vocalization was not performed, supporting the view that "both orthography and phonology contribute to the activation of the meaning of written words" (Sakuma et al., 1998, p. 85). By displaying kanji in different parts of a viewing terminal, thus directing the reader's attention to the left or right visual fields during kanji processing, Nakagawa found evidence of "two types of visual representation computed in distinct brain systems during encoding of visual words" (Nakagawa, 1994, p. 873). One type processes specific visual information such as line patterns, and the other type processes abstract information in order to identify words (1994, p. 874). These findings support a dual-route model of processing that is characterized by the coaction of (a) form-specific character content with (b) abstract information about the lexical item. This interaction of (a) and (b) above can be summarized by saying that "knowledge of kanji phonology, orthography, and semantics interrelates to construct overall kanji knowledge" (K Tamaoka & Yamada, 2000, p. 205).

### 2.4.3 Anatomical basis for processing differences

With increasing interest in kanji processing, there has been some research on the processing of Japanese kanji on a neurological level (e.g. Thuy et al., 2004; Ino et al., 2009; Ischebeck et al.,

2004; Matsuo et al., 2010), using data from MRI scans, and behavioural data from experiments on subjects with language impairments such as aphasia and surface dyslexia. If the findings of neurological studies match the predictions of a dual-route processing model, it would provide evidence of an anatomical basis for the model, with dual physical pathways providing the functionality described in the dual-route processing model. If such an anatomical basis for dual-route processing was confirmed, it could potentially have pedagogical implications, allowing educators to design kanji learning materials in a way that exploits the processing mechanism, potentially increasing the effectiveness of the learning process.

Nakagawa (1994) investigated whether one brain hemisphere may have processing advantages over the other in reading Japanese. Subjects' attention was directed to alternate visual fields during lexical tasks. In doing so, it was discovered that kanji showed a processing advantage in the right side of the brain, but only for single-character kanji words (Nakagawa, 1994, p. 864). This is of note because the authors found that two-character kanji words were processed more like English, with a left hemisphere advantage (1994, p. 871), explicitly pointing to processing differences between reading kanji and reading English. Nakamura et al. (1998) tested the reading abilities of $L1^{morph}$ subjects with Alzheimer's disease, finding that kanji reading accuracy became more impaired than kana reading accuracy as the severity of the disease progressed (1998, p. 241). The authors suggest that anatomical differences in kanji reading mechanisms could be the cause, stating "the preferential impairment of kanji reading might be related to the neuropathological change in Alzheimer's Disease which involves these structures" (Nakamura et al., 1998). Finally, they noted that some patients were able to read the kanji without actually comprehending them, leading the authors to conclude that "kanji can be read correctly without meaning" (1998, p. 237).

Higuchi et al. (2015) used MRI imagery to map and compare $L1^{morph}$ subject responses to real kanji, pseudo kanji, and artificial characters. This was done in order to isolate different components within the characters themselves and test whether different brain activation patterns might be

observed. Indeed, they found that "neural activation differentiates the elements in Kanji characters' fragments, subcomponents, and semantics, with different patterns of connectivity to remote regions among the elements" (Higuchi et al., 2015, p. 1). This suggests that the information contained in different components of kanji can produce a processing interaction that has its basis in different locations of the brain. Sakurai et al. (1997) detailed the unusual cases of two patients, each exhibiting different symptoms of agraphia[10]. In dictation tasks, one patient could write words in kana but was unable to write the same words in kanji. The other patient performed better with kanji than kana in the same tests, often having difficulty in recalling kana (1997, p. 946). MRI imagery revealed brain lesions in both patients, with the lesions being situated in different locations. To explain these findings, the authors propose a two-path processing model consisting of a "phonologic" route and a "morphologic" route (Y Sakurai et al., 1997, p. 950). Sakurai (2019) compared lesions in different areas of the brain and correlated them with symptoms relating to kanji-kana dissociation. He found that damage in specific areas of the brain could create language disorders that specifically affected either the processing of phonograms (kana) or morphograms (kanji) (2019, p. 53).

While studies such as the above provide reasonable evidence of an anatomical basis for the dual-route model, it should be noted that these conclusions have also been challenged, as some data indicates that the variance shown in brain activation may be indicative of task-based differences rather than anatomical differences. For example, Nakamura et al. (2002) found that "the neural systems for processing the two different scripts are separable only functionally, rather than anatomically" (2002, p. 112). This view is shared by Ino et al. (2009), who found that some reading-aloud tasks produced no differences in brain activation, whereas word recognition tasks did (2009, p. 231). Despite these objections, there appears to be a growing body of evidence that the dual-route processing model may have a physical, anatomical basis in the brain. These findings are relevant to this study because the use of such L1 data as a resource may be able to highlight some

[10] Agraphia is characterized by "an impaired ability to spell irregular and ambiguous words, and a preserved ability to spell regular words and nonwords" (Y Sakurai et al., 1997, p. 946).

commonalities between L1 and LX readers. As mentioned in Section 2.3, there is evidence that kanji composition can affect LX processing, meaning that there could be implications for educators who seek to adapt L1 learning strategies and justifiably employ them in LX learning environments.

### 2.4.4 Frequency and consistency

This section discusses studies that examine how lexical frequency[11] and print-to-sound consistency[12] impact L1 kanji processing. It is important to look briefly at these factors for two reasons. Firstly, findings from studies testing these factors can provide further support for the dual-route processing model or its anatomical basis. Secondly, if kanji are to be used as stimulus materials in any type of experimental intervention in this study, it is necessary to consider to what degree these factors might be relevant so that the methodology can be properly calibrated.

There are two main categories of readings in Japanese; native Japanese readings called 'KUN-yomi' and readings originally borrowed from Chinese called 'ON-yomi'. For characters with several possible readings, the question of which reading is correct in a given instance is the question of its consistency. Wydell et al. (1995) offer the example of the character 親 (parent). Since it is read as '*oya'* in some two-character words (such as 母親 *hahaoya* - mother) and '*shin'* in other two-character words (such as 親友 *shinyuu* - close friend), any two-character word containing it "can therefore be described as an inconsistent word because pronunciation of the character varies across the orthographic neighborhood of words containing it" (Wydell et al., 1995, p. 1156). While there tends to be a dominant KUN-yomi or dominant ON-yomi for most kanji characters, there is a disparity between how often the dominant reading occurs relative to the less common readings. It is

[11] Twomey et al. (2013), note that in Japanese it is possible "to disentangle the frequency of a written word (i.e. its lexical frequency) from the frequency of its visual form (i.e. its visual familiarity)" (2013, p. 184). Thus, for many studies in Japanese, the term 'frequency' refers to the lexical frequency of an item, irrespective of which script it is written in, unless otherwise indicated.

[12] 'Consistency' has been defined as "the degree of congruence in the pronunciations of the characters within a family" (Shu et al., 2003, p. 39), or "various degrees of consistency in subword print-sound correspondences" (Fushimi et al., 1999, p. 382). In simpler terms, consistency broadly relates to how regular a particular reading of a kanji character is.

this disparity that creates consistency effects**.** The difficulty of assigning a numerical value to consistency, which is not a readily quantifiable attribute, has been a recurring methodological issue in the literature. Authors recognise that consistency can be easily influenced by frequency (Kayamoto et al., 1998; Yamazaki & Ellis, 1997), and therefore conclusions about these factors are often considered in tandem.

In terms of how frequency and consistency impact processing, studies involving lexical naming tasks (Balota & Chumbley, 1985; McCann & Besner, 1987) provided a transferable framework for testing on kanji and kana. In more detailed testing using naming tasks with kanji, Wydell et al. (1995) conducted six experiments that tested reaction times and accuracy of kanji word naming in $L1^{morph}$ participants. The experiments were designed to understand the role of consistency in character-to-sound correspondences when reading kanji, using both single-character and two-character Japanese words as stimuli. They found significant effects produced by character frequency and visual familiarity but failed to find conclusive evidence of consistency effects (1995, p. 1155). This finding prompted further investigation by Kayamoto et al. (1998), who suggested two potential methodological issues that may have generated erroneous findings in the Wydell study. The Kayamoto et al. (1998) naming task experiments on $L1^{morph}$ readers compared single-reading kanji to multiple-reading kanji and correlated reaction times with word frequencies. They found clear differences in subject reaction times produced by consistency effects, such that "the single-reading kanji were named faster than were the multiple reading kanji regardless of their frequency" (Kayamoto et al., 1998, p. 625). They also describe an anecdotal account of how their subjects named the words by mentally generating a possible reading permutation and consulting their lexicon to see if such a word existed (Kayamoto et al., 1998, p. 632). Although empirically unsubstantiated, this describes a process whereby the phonology of some kanji is computed prior to lexical access.

Hino and Lupker (1998) also conducted naming tasks and lexical decision tasks, using katakana and kanji as stimuli on L1$^{morph}$ kanji readers. They found that frequency effects were only more prominent in kanji for naming tasks (but not for lexical decision tasks), which is consistent with dual-route processing theories (1998, p. 1431). Fushimi et al. (1999) produced several findings of note, including an assertion that frequency effects in reading kanji were more pronounced than in English (1999, p. 397) and that the interaction of frequency and consistency produces significant effects when naming kanji (1999, p. 382). Nakayama et al. (2014) tested this by using kanji words of varying frequencies in a technique called 'masked priming'[13]. In the experiments, one condition was to show a mask word (選手) and a prime word (助手) that share the same character 手. By manipulating various conditions in the masks and primes (such as frequency and consistency), it was possible to detect a difference in the kind of inhibitory effects seen between English and kanji in similar masked priming experiments (2014, p. 813). It was found that "neither low frequency word neighbors nor nonword neighbors have an ability to affect high-frequency targets, even if the primes have many neighbors" (Nakayama et al., 2014, p. 828). These findings seem to indicate that processing is affected significantly by frequency and consistency and that an interaction of these factors may compound the degree of influence.

In summary, there is a reasonable body of evidence that suggests that both lexical frequency and consistency have clear effects on L1 kanji processing. A facilitatory effect was observed in the case of both high-frequency words and characters that had consistent readings. These findings would only be possible if kanji processing was performed in a way that is predicted by the dual-route model, i.e. that both lexical and sub-lexical factors are interacting in the processing mechanism. Therefore, the findings provide further support for the dual-route model of kanji processing. Furthermore, the studies indicate that the use of kanji as stimulus materials must take into account the potential influence of these factors.

[13] Masked priming is a process whereby a target word (the 'prime') is shown only after another word (the 'mask') is briefly shown to subjects (Kinoshita & Lupker, 2003, p. 4). The technique is useful for examining processing under different experimental conditions.

### 2.4.5 Processing and kanji composition

This section summarizes studies that investigate the importance of character composition in the processing of kanji. Of particular relevance is how radicals (or components in general) and visual complexity[14] can influence processing.

#### 2.4.5.1 Radicals

As mentioned in Section 2.2.1, kanji are generally divided into four categories. Many characters in these categories contain a dominant 'radical' component, accompanied by other components. There are 214 radicals in the traditional Kangxi categorization system (Tamaoka et al., 2017), with kanji characters often classified according to which radical they contain. Since radicals often contain semantic information, it is reasonable to hypothesize that they may exert some influence on processing. Indeed, this was a basic assumption in the research of Tamaoka and Yamada (2000)[15]. To test the validity of this assumption and to explore how other compositional features (such as stroke order) contribute to kanji knowledge in L1$^{morph}$ readers, they measured lexical knowledge of kanji in five conditions. They tested (1) knowledge of stroke order, (2) knowledge of radicals, (3) knowledge of kanji lexical orthography, (4) knowledge of kanji lexical phonology, and (5) knowledge of kanji lexical semantics. The findings showed a statistically significant correlation between radical knowledge and lexical knowledge (2000, p. 203). They also found an intercorrelation between lexical knowledge and phonology, orthography and semantics, leading the authors to conclude that knowledge of radicals "shows significant direct contributions to all knowledge of kanji phonology, orthography and semantics" (2000, p. 205). Tamaoka and Yamada (2000) conclude that knowledge of radicals "acts as a basic building block of lexical knowledge in all aspects of kanji orthography, phonology, and semantics" (2000, p. 208). This is a key finding because it emphasizes the interdependence of the different compositional features of kanji in processing and provides further evidence that kanji are processed by an interaction of routes that parses both semantic and phonological information. The study found that knowledge of stroke

[14] Visual complexity in this context is considered to be distinct from non-language counterparts such as icons, as some evidence suggests that the brain treats these phenomena differently (Huang, Bias, & Schny, 2015, p. 702).

[15] Tamaoka and Yamada (2000) point out that "the top ten most frequently-used radicals are used to construct about 34% of the 1945 basic kanji" (2000, p. 201). The literacy list was updated in 2010, increasing the number of required kanji from 1945 to 2136 (Ministry of Education, Culture, Sports, Science, 2010).

order did not play an important role in kanji lexical knowledge (2000, p. 208). This study is supported by a more recent study using MRI image scans. Higuchi et al. (2015) used real kanji, pseudo-kanji, and artificial kanji as stimuli in fMRI sessions with L1$^{morph}$ subjects, visually presenting the characters during the scans. They found that elements (components) are distinguished visually before formulating connections in other parts of the brain. This was not observed for pseudo-kanji control items, indicating that processing may rely on a synthesis of compositional recognition, which includes radicals and other components, and which takes into account phonological information (Higuchi et al., 2015, p. 14).

#### 2.4.5.2 Visual complexity

In addition to composition, it has been shown that visual complexity can influence kanji processing (e.g. Koyama, Hansen, & Stein, 2008; K Tamaoka & Kiyama, 2013). Early models of how visual complexity impacts kanji processing involved assigning numerical values to compositional features of kanji. For example, Kawai (1966) proposed a model that calculated the aggregate number of lines and points of intersection in a given kanji character. Using this method, Kawai found a correlation between high-frequency characters and characters that had been assigned high numbers in his model, concluding that high visual complexity could have facilitatory effects on kanji processing (1966, p. 1). Subsequent efforts to quantify visual complexity reduced the phenomenon to stroke count. For example, Kaiho (1979) suggested that visual complexity only facilitates kanji processing when the degree of complexity is large, i.e. more than 12 strokes. A later study by Tamaoka and Takahashi (1999) found that low-frequency kanji words can actually undergo an inhibitory processing effect influenced by visual complexity (1999, p. 45).

There is also some fMRI data that provides evidence that visual complexity affects processing. Comparing kana and kanji, Thuy et al. (2004) found that "the neural processing for kanji and kana appears to be different. One possible factor contributing to the discrepancy could be the different visuospatial or configurational complexities of the two types of scripts" (2004, p. 886). Taking the findings of such studies into account, Tamaoka and Kiyama (2013) revisited the question of visual complexity by performing experiments using kanji lexical decision tasks and kanji naming tasks.

Their experiments used stroke count as the primary measure of visual complexity, and they divided the stimulus kanji characters into low-complexity characters (2-6 strokes), medium-complexity characters (8-12 strokes), and high-complexity characters (14-20 strokes), based on guidelines outlined in a government document (Cabinet Announcement by the Japanese Government, 1981). It was found that kanji of medium-complexity were processed faster than either low-complexity or high-complexity kanji (Tamaoka & Kiyama, 2013, p. 205). Findings also included corroboration of earlier findings that "visual complexity inhibited the processing of low-frequency kanji" (Tamaoka & Kiyama, 2013, p. 205).

Eye-tracking studies have provided a parallel source of investigation of visual complexity. White et al. (2012) found that "words containing visually complex kanji characters take longer overall to process compared to words containing visually simple kanji characters" (2012, p. 999). The authors carefully controlled for the frequencies of words and characters, as well as word length, allowing for the robust conclusion that "in this study it was the visual complexity of characters, as measured by the number of strokes, which influenced reading behaviour" (2012, p. 999). Another eye-tracking study found differences in reading patterns between Japanese children and adults, with children spending more time fixated on morphographic kanji words than on phonetic hiragana words (Jincho, Feng, & Mazuka, 2014, p. 1437). The authors conclude that normative reading skills are developed over time by a process of differentiating between character types (in children) and that this eventually becomes a character-independent process (in adults) (2014, p. 1460). This finding is evidence that visual complexity in kanji can play a role in the development of reading, in that differentiation between visually complex morphographic scripts and a more visually simple phonetic script is a necessary skill for formulating reading skills. Overall, the evidence from the studies cited above suggests that visual complexity can influence kanji processing to some degree. As with frequency and consistency, this should be a consideration when using kanji as source materials for any experimental process. It may also have pedagogical implications for teachers when designing a curriculum or deciding on teaching materials.

### 2.4.6 Processing summary

This section has presented summaries and discussions of studies relating to L1$^{morph}$ kanji processing. The findings generally support the hypothesis that kanji are processed as described by a dual-route model of processing. A dual-route model predicts that kanji are processed by means of an interaction between a lexical route and a sub-lexical route. This means that semantic and phonological information both play a crucial role in efficient kanji processing. Lexical frequency and consistency (of readings) were also seen to influence kanji processing, lending further support to the dual-route processing model since it would not be possible unless both lexical and sub-lexical factors were at play. While the data support the model, there is still some debate as to whether it has corresponding dual-pathway anatomical counterparts in the brain. In terms of composition, there is reasonable evidence that knowledge of radicals and components forms a fundamental basis for efficient kanji processing, with several studies demonstrating that knowledge of radicals affects a range of skills in reading Japanese. Visual complexity, as measured by stroke numbers, was seen to have inhibitory effects for simple and complex kanji but facilitates the processing of kanji of medium complexity.

## 2.5 Towards the identification of a kanji learning strategy for analysis

### 2.5.1 Introduction

The previous section explored kanji processing by L1$^{morph}$ readers and the various factors that can affect its underlying processing mechanism. This section examines some key issues in LX kanji learning, with the aim of understanding the key challenges faced by LX learners. By integrating the findings from L1$^{morph}$ processing into a discussion of LX kanji learning, the goal is to identify one specific LX kanji learning strategy as a suitable candidate for further detailed examination. As such, this section seeks to understand (1) the nature of the differences between L1 and LX kanji processing, (2) the possible causes of those differences, and (3) the pedagogical implications. Section 2.5.2 outlines some of the main differences between how L1$^{morph}$ readers and LX readers

process kanji. Section 2.5.3 discusses the possible causes of those differences by examining theoretical arguments and experimental data relating to cross-linguistic transfer. The pedagogical implications of the above arguments are presented in Section 2.5.4. Other factors that are relevant to LX learning, such as behavioural factors, are mentioned briefly in Section 2.5.5, although these are topics that generally fall outside the scope of this thesis.

### 2.5.2 Differences in kanji processing between L1 and LX

In order to integrate $L1^{morph}$ processing data with a discussion of LX kanji learning issues, it is necessary to identify the kinds of processing differences observed between the groups. One way to carry out this comparison is to analyse the differences between how these two cohorts produce errors when writing kanji, as Hatta et al. (1998) indicate. If kanji are processed by an interaction of lexical and sub-lexical routes, the qualitative nature of writing errors allows for inferences to be made about the underlying processing mechanism that produced the errors. The experiments in Hatta et al. (1998) make an explicit link between the cognitive processes of L1 and LX readers since “kanji writing errors of segment mis-arrangement were common for both our Japanese and Australian subjects” (1998, p. 469). They collected and analysed kanji errors in the writing of $L1^{morph}$ Japanese students and compared them to the writing errors produced by LX learners of Japanese. They found that the $L1^{morph}$ group made mostly phonological errors, such as writing a homophonous but incorrect kanji. On the other hand, LX students made many more orthographic errors, such as including additional strokes or placing segments in incorrect formations (Hatta et al., 1998, p. 466). One possible explanation is that they are focusing on orthographic representations rather than apprehending the individual components in the character, as suggested by Hatta et al. (1998). Analysing such errors, they conclude that "semantic, orthographic and phonological factors all contribute to the production of incorrect kanji candidates" (Hatta et al., 1998, p. 311). It is clear they consider this relevant to kanji pedagogy as they emphasise that "the phonological aspect of kanji morphemes should also be taken into consideration for the teaching of kanji writing" (Hatta et al., 1998, p. 314).

Another way to understand L1 and LX differences is to examine how they both process semantic and phonological information in kanji. A study by Toyoda (2000) examined how accurately English-speaking learners of Japanese could distinguish the various components in kanji characters. This was an attempt to ascertain the degree to which semantic and phonological components were being processed while reading kanji. It was found that these LX learners had the ability to differentiate between the components but appeared to be more skilled at using semantic components than phonological components (Toyoda, 2000, p. 1). Similarly, in a study by Tanaka (2015), $L1^{logo}$ (Chinese) learners were seen to have trouble extracting phonological information because of an over-reliance on a semantic-based comprehension strategy when reading kanji. The experiments tested the degree of phonological involvement in the word recognition by the $L1^{logo}$ learners of Japanese, finding that "they do not activate phonological representations while reading Japanese cognates" (2015, p. 900). In contrast, when $L1^{morph}$ readers process kanji, the phonological information is extracted efficiently and plays a key role in word recognition. For example, when Morita (2019) tested the role of silent reading by native Japanese readers, she found that "phonological activation is included in Japanese sentence acceptability judgment" (2019, p. 515) and that it appeared to be an important aspect in determining whether a sentence was acceptable or not.

Differences between L1 and LX may also manifest in their sensitivity to kanji compositional features. Studies specifically examining the role of memory provide evidence of the importance of striving to develop compositional awareness in learners. For example, Chikamatsu (2005) compared the kanji memory retrieval errors of L1 and LX participants through the 'tip of the pen' (TOP) phenomenon, which she describes as when "a kanji character in the word is stuck on the tip of the pen and cannot be written accurately, although the person thinks he/she knows it" (2005, p. 72). This is the state wherein the learner is attempting to retrieve the kanji from memory. By categorizing the types of errors made by the two cohorts during that memory retrieval state, Chikamatsu argues that it can provide insights into kanji processing mechanisms and how it relates to memory. There was a significantly higher rate of LX errors related to incorrect components,

indicating that the gap between recognition and production in LX learners may be much larger than previously thought (2005, p. 81). She makes the following pedagogical recommendation:

> "One possible approach is to enhance kanji production skills is to select high-frequency radicals as functional lexical units, and to teach characters as an assemblage of those radicals rather than of several single strokes. Even if the radical is semantically or phonetically opaque in a given character, the knowledge of radicals may help a learner memorise and write characters more efficiently and precisely" (Chikamatsu, 2005, p. 90).

Sensitivity to compositional elements (or lack thereof) might even impact how successfully a reader can utilize contextual clues when reading kanji. Okita (2019) used erroneous kanji characters in single-character and full-sentence contexts and tested the effects these different environments had on $L1^{morph}$, $L1^{alpha}$, and $L1^{logo}$ kanji readers. He found that facilitating contextual effects were only observed in $L1^{morph}$ readers, indicating that their sensitivity to compositional features gave them an advantage over the LX readers in availing of sentence-level cues (Okita, 2019, p. 1). This finding suggests that LX learners experience a compounding-of-problems effect in reading kanji, which stems from difficulties they have in distinguishing compositional details in kanji characters.

Another difference between the groups is that the inherent opacity of kanji phonology seems to be a significant obstacle for LX learners. Toyoda (2009) indicated that the multiplicity of possible readings of kanji might be the source of what she calls "the slow development of phonetic awareness in Japanese" (Toyoda, 2009, p. 16). This is supported by Kubota and Toyoda (2001), who tested kanji learning by asking LX learners of Japanese to memorize the meanings of words written in kanji. While memorizing the words, subjects were asked to 'think out loud' so that their thought process and learning strategy could be monitored. It was found that the highest rates of correct recall were exhibited by those who paid particular attention to the semantic radicals, with the authors concluding that "recognition of radicals and analysis of whole words were effective for memorizing the words written in kanji" (Kubota & Toyoda, 2001, p. 1). Such findings are

interesting when taken in the context of other studies, such as Koda (1989), in which four groups (learners of Arabic, English, Japanese, and Spanish) were subjected to two different kinds of phonological interference [“phonological similarity and unpronounceability” (1989, p. 201)]. Koda found that while the short-term memory recall of all groups was impaired by the interference, there were differences in how it affected phonographic languages (like English) and morphographic languages (like Japanese) (1989, p. 201).

Taken together, the findings from the studies above suggest that there are qualitative differences in the way that $L1^{morph}$ kanji users and LX kanji users process the characters. These differences appear to be rooted in the same dual-route processing model while manifesting as variations in which routes are prioritized. Sensitivity to semantic radicals is something which both groups share, as attested to by increased accuracy by those who relied on radicals to reproduce kanji. However, the studies suggest that LX users have a tendency to rely too heavily on semantic radicals because they have difficulty developing effective skills in the phonological processing of kanji. This may be caused by the multiplicity of possible pronunciations of kanji, as suggested by Toyoda (2009) above, but it may be compounded by the way in which learners use their L1 phonological coding mechanisms in the LX target language. This has potentially serious implications, for if the mechanisms of phonological processing are carried over from a learner's L1 orthography to the target language, it could present difficulties for prospective learners. In particular, languages with incongruent orthographic systems could present serious challenges.

The findings above also raise the question of whether ‘LX learners of Japanese' is too broad a term. If L1 orthographic background can be seen to have a significant effect on kanji processing, it may be better to differentiate learner language backgrounds into phonographic (such as alphabetic languages) and logographic (such as Chinese). As discoveries by scholars such as Kato (2005), Wang (2003), and Machida (2001) suggest, there is evidence that these groups need to be treated differently. For example, Machida (2001) compared Japanese text comprehension by Chinese and

non-Chinese background learners and found that the two groups displayed distinct differences in the types of strategies they employed to understand the texts. The Chinese group favoured meaning-based strategies and "were more logographically-oriented than the non-Chinese background subjects" (Machida, 2001, p. 113). Kato (2005) showed that Chinese learners of Japanese rely heavily on associating semantic aspects between the two languages when they attempt to write Japanese words (2005, p. 283). Even studies on Chinese that do not involve any explicit comparisons with other languages can be relevant to this question. In developing literacy in Chinese, Chan (1998) found that "children were able to use semantic radicals to represent meaning" (1998, p. 115), demonstrating that morphological awareness of radicals develops early. In yet another recreation of the Van Orden (1987) homophony experiment, Wang et al. (2003) compared Korean and Chinese ESL performances on semantic category tests. They found that the Korean group relied more on phonological cues than the Chinese group, attributing the difference to the fact the Korean is more similar to an alphabetic language (Wang et al., 2003, p. 145). These studies suggest that in discussing LX kanji learning, it may be better to differentiate between $L1^{alpha}$ learners of Japanese and $L1^{logo}$ learners of Japanese.

### 2.5.3 Cross-linguistic transfer

Given the evidence that orthographic background may play a significant role in LX kanji learning, it is important to explore the issue of cross-linguistic transfer both from a theoretical standpoint and in light of experimental data. This section discusses two hypotheses relating to orthographic influence, as well as experimental data from studies on ESL and JFL.

#### 2.5.3.1 Influence of orthography on processing

There have been various attempts to explain the relationship between a given orthography and the mechanisms at play when processing it. One consideration in defining that relationship is the interplay between the orthographic regularity of a language and other factors that affect processing, such as frequency and consistency. For example, the 'Orthographic Depth Hypothesis' (ODH) postulated by Katz and Frost (1992) predicts that processing differences mainly arise from the correspondences between graphemes and sound in a given orthography. This hypothesis uses the

analogy of shallowness or depth to describe how closely the script of a language corresponds to its spoken version. Katz and Frost (1992) note that there is a preponderance of languages in existence and that "the range of correspondence between grapheme and phoneme varies both in consistency and completeness" (1992, p. 147). Some languages (such as Croatian) are characterized by a very close consistency of graphemes to phonemes - this is known as a 'shallow' orthography. Other languages (such as Hebrew or Japanese) show a far more complex relationship between graphemes and phonemes - this is known as a 'deep' orthography. For alphabetic languages, the concept of depth for an orthography is essentially the "transparency of their letter-to-phoneme correspondence" (Katz & Frost, 1992, p. 150). This is relevant to the analysis of kanji processing by LX learners because one of its predictions is that phonological coding will be the default mode of processing for $L1^{alpha}$ learners of Japanese. A learner who is accustomed to regular letter-to-phoneme correspondences will, according to the hypothesis, have difficulty adjusting to an orthography that has a more complex grapheme-to-phoneme relationship. This could result in the kind of over-reliance on semantic processing that was seen in the findings discussed above since the reader will struggle with the ‘depth’ of the orthography. In other words, if orthographic features are responsible for processing differences, as the hypothesis predicts, it could manifest as learning difficulties for kanji learners who are not accustomed to morphographic scripts.

A different hypothesis, known as the 'Direct Access Hypothesis' (DAH) (Seidenberg, 1985; Jared, McRae, & Seidenberg, 1990; Seidenberg & McClelland, 1989), predicts that processing differences are attributable to how familiar the word is, with familiar high-frequency words being processed differently than low-frequency unfamiliar words, irrespective of orthographic regularity. This hypothesis is originally based on observations from a study that compared word recognition in English and Chinese. A key finding of the study was that "in each writing system, a large pool of higher frequency words is recognized on a visual basis, without phonological mediation" (Seidenberg, 1985, p. 1). Thus, Seidenberg insists that processing printed words can be accomplished by relying on either visual or phonological cues. The deciding factor is the all-important magnitude of word frequency, not the specific features of the orthography. He claims

that “which route dominates for a given word depends on factors such as frequency and reading skill” (Seidenberg, 1992, p. 99). He concludes that word frequency can provide a kind of fast-track direct processing without the need for phonological mediation. Furthermore, this type of processing is available no matter what the orthography happens to be. In other words, the hypothesis posits a universal faculty for processing that interacts with a target language in predictable ways irrespective of orthographic background. Seidenberg concedes that orthography exerts some influence in word recognition but insists that "differences in the manner in which they represent phonology are not relevant to the recognition of common words" (1985, p. 1). Seidenberg later revised this hypothesis to recognize a somewhat larger role played by orthography, but at its core, the claim still remains that "a common, multi-component architecture underlies processing in different orthographies" (Seidenberg, 1992, p. 88). The implications of this hypothesis also have relevance to Japanese, for if word frequency is the dominant factor in word recognition, a greater role must be attributed to whole-word processing of high-frequency words in kanji. Furthermore, if L1 orthographic background exerts minimal influence on LX processing (as is claimed), there would be no need to differentiate between $L1^{alpha}$ and $L1^{logo}$ learners of kanji, for example. It may also be the case that the two hypotheses described above are not mutually exclusive and that frequency and orthographic depth both play a key role in processing.

#### 2.5.3.2 Experimental studies

Akamatsu (2002, 2003, 2005) has investigated cross-linguistic transfer in great detail, carrying out several studies under a variety of experimental conditions. He tested the word recognition of fluent ESL readers from Chinese, Japanese and Persian backgrounds. Words of varying frequency, regularity, and exception words were used as stimuli. The findings of that study align with predictions of Seidenberg’s Direct Access Hypothesis, in that "the nature of L1 orthography did not affect L2 word-recognition processing" (2002, p. 12). Akamatsu (2003) conducted further tests with another study of ESL readers from the same backgrounds as the above study to examine the effects of upper and lower cases on processing. This time, words in the text were presented either in alternated case (e.g. "thErE") or under normal conditions (e.g. "there"). He found differences in how readers processed the altered case words, finding that "because of L1 effects on basic

processing in L2 reading, L2 readers with a nonalphabetic L1 background were less efficient in processing English words than those with an alphabetic L1 background." (Akamatsu, 2003, p. 207). A further study, Akamatsu (2005), examined whether L1 orthographic effects were different according to the proficiency level of the reader. This time, he used all $L1^{morph}$ learners of English of varying proficiency levels. Again, word recognition reaction times were tested and correlated with frequency. He found statistically significant frequency effects between the cohorts, in that the "more proficient L2 readers recognised English words more quickly and more accurately than less proficient L2 readers" (Akamatsu, 2005, p. 252). However, those processing advantages were not evident under the altered-case condition since "the effects of word regularity on word recognition accuracy disappeared with the loss of word-shape information due to case alteration" (Akamatsu, 2005, p. 252). This is a particularly relevant finding to the current study as it suggests that L1 orthographic differences may supersede word frequency or LX proficiency in terms of the magnitude of their influence. Akamatsu (2005) states that "considering the present study's findings, one could speculate that L1 orthographic features may deeply affect L2 word-recognition development" (Akamatsu, 2005, p. 254).

Sasaki (2005) compared L1-Italian and L1-Japanese learners of English by giving them semantic category 'odd-one-out' tests and memory tests. She found that the Japanese group showed an "inefficiency in recognising words in an unfamiliar writing system" (Miho Sasaki, 2005, p. 302). Similarly, Koda (2000) presents her empirical study on cross-linguistic transfer by comparing two groups of English learners, one group having a Chinese L1 background and the other group having a Korean L1 background. Subject responses were recorded under a variety of experimental conditions to measure intra-word sensitivity, analysis accuracy and contextual integration (Koda, 2000, p. 307). Findings showed that "Chinese learners were … far more efficient in integrating morphological and contextual information during sentence processing" than Korean learners (Koda, 2000, p. 297). Koda (2005) presents a metastudy that further supports this, concluding that "research findings seem to suggest that orthographic distance is a strong predictor of second-language decoding development" (2005, p. 325). These findings highlight differences in how

different cohorts process a target language based on the features of their L1 orthographic background, as predicted by the Orthographic Depth Hypothesis.

Scholfield & Chwo (2005) found supporting evidence for the Direct Access Hypothesis in their study comparing Chinese L1/English LX learners from Hong Kong and Taiwan. Subjects were asked to match the meanings of word pairs in Chinese and English, and reaction times were tested. It was found that word frequency, as well as the influence of the language environment, had far more powerful effects than L1 background (Scholfield & Chwo, 2005, p. 231). Grainger (2005) found that for LX Japanese learners, incongruent orthography did not detrimentally affect their performance as quantified by a strategy measurement survey called SILL (Horwitz & Oxford, 1991). Chikamatsu (2006) suggests that while L1 orthographic influence exists, it can be mitigated with LX practice. In testing the word recognition strategies of two groups of $L1^{alpha}$ learners of Japanese, she found that "phonological dependency affected by L1 orthographic features diminishes as proficiency advances from novice to intermediate levels" (Chikamatsu, 2006, p. 77). This conclusion is shared by Liu et al. (2006), who found that $L1^{alpha}$ learners of Chinese were able to develop new mechanisms that resemble native processing models after only two semesters of learning Chinese (2006, p. 652). Hamada (2008) also finds that while both L1 and LX effects are manifested in the target language, "L2 input exerts a more powerful impact on L2 decoding than transferred L1 competencies" (2008, p. 16). In other words, there seems to be evidence that there is a developmental factor at play, whereby the effects of L1 orthographic background can be mitigated somewhat by increased exposure to the target language.

As the findings from the studies in this section suggest, it does not appear to be a simple either-or case. There is reasonable evidence that features of an L1 orthography can have an explicit influence on LX word processing, as predicted by the Orthographic Depth Hypothesis. Simultaneously, features of the target language such as word frequency and LX exposure seem to have an undeniable effect, as predicted by the Direct Access Hypothesis. It seems most likely that an

interaction of both these factors can be postulated as a reasonable explanation for the underlying cause of observed processing differences between L1 and LX readers.

### 2.5.4 Pedagogical implications

Given the above findings, there are several questions that naturally arise regarding what the consequences may be for pedagogical practices in LX kanji learning. For example, if $L1^{alpha}$ learners of Japanese attempt to process kanji in a way that is predicated on their L1 processing mechanism, they may have trouble developing the kind of efficient dual-route processing that is seen in $L1^{morph}$ kanji readers. If that were the case, there might be ways to design curricula, learning strategies, and teaching materials in a way that recognises the importance of mitigating those lingering disadvantages that can arise from L1 orthographic influence. For example, it could be possible to adapt kanji learning specifically for a particular type of learner. Learners from alphabetic backgrounds could benefit from a strategy that emphasizes components of kanji characters in specific language tasks (e.g. Kubota & Toyoda, 2001), allowing them to develop the skill of extracting both semantic and phonological information from kanji. While there is evidence that explicitly teaching radicals is an effective approach with the Chinese language (Taft & Chung, 1999), there is still little empirical evidence to indicate how effective this may be for LX learners of Japanese, despite explicit recommendations such as the following:

> "In order to bring L2 readers up to the most refined phase of character recognition development, repeated training for strengthening reliable links between units may be necessary. For example, when new words are introduced, L2 readers should be encouraged to pay attention to individual constituent characters, and to examine how the characters are, or are not, related to the word. For each of the constituent kanji, if it is a compound character, L2 readers should be assisted in analysing how the semantic information in the bushu is, or is not, related to the meaning of the character."
> (Toyoda & Mcnamara, 2011, p. 403)

Another critical question is the developmental issue, i.e. whether L1 orthographic background effects are more prominent in lower levels of LX proficiency and whether they can be eliminated by means of specific types of instruction as proficiency develops. In relation to Japanese, this would involve attempting to shift a learner's mode of processing from an over-reliance on one processing route or another to a more holistic usage of both semantic and visual cues within kanji. In the study analysing kanji writing errors (Hatta et al., 1998) discussed above in Section 2.5.2, it was seen that LX learners of Japanese tended to make a lot of orthographic mistakes, indicating failed attempts at using visual recognition as a means of processing kanji. This conclusion is supported by Matsumoto (2013), who gave lexical decision tasks to $L1^{alpha}$ and $L1^{logo}$ kanji learners. The participants were shown kanji and were asked to decide whether the on-screen meaning matched the displayed kanji. The kanji displayed were a mixture of homophonic, homographic, and real words, making it possible to make inferences about processing mechanisms based on accuracy rates for each type of word. He found that "learners with L1 alphabetic knowledge use a visual recognition strategy rather than phonological processing; however, due to insufficient sensitivity to individual kanji characters, learners with L1 alphabetic knowledge seemed to make mistakes" (2013, p. 170). This is a key point. Due to the influence of their orthographic background, $L1^{alpha}$ kanji learners seem to be attempting to use their predominantly visual processing mechanism to decode a target language (written Japanese) that requires more awareness of the components. In other words, they tend to see the characters as a collection of strokes and are trying to process them on that basis. Failing to perceive the characters as discrete clusters of components results in difficulty in extracting the relevant information from the components. It is as if the brain is attempting to use visual recognition as a default but is failing because the learner has not been able to successfully parse both the semantic and phonological information in the components. Some researchers have recognized this difficulty and offered recommendations on how to overcome it. For example, Yamashita and Maru (2000) propose introducing kanji based on compositional features so as to familiarize the learner with kanji components gradually. They suggest teaching kanji in the following order: pictographs → katakana composites → semantic composites → semantic-phonetic composites (H. Yamashita & Maru, 2000, p. 170). By doing so, they argue, the learner can gradually develop a holistic

interpretation of kanji without being overwhelmed in the early stages of learning. Hagiwara (2016) also notes the importance of an integrated approach by recommending "parallel reinforcement of orthographic-semantic and orthographic-phonological connections" (2016, p. 890). She explicitly recommends providing spoken pronunciation when teaching phonetic radicals. Chikamatsu (2005) offers several recommendations, including using more contextual activities to offset the difficulty of dealing with multiple kanji readings, and to "select high-frequency radicals as functional lexical units, and to teach characters as an assemblage of those radicals rather than of several single strokes" (2005, p. 90). In a meta-study on salient issues in Japanese pedagogy, Mori and Mori (2011) note that even though students "were able to combine information from kanji components and sentential context" (2011, p. 452) that they tended to rely on one or the other, again pointing to the importance of implementing an integrated approach during LX kanji instruction.

However, it remains to be seen how the developmental nature of cross-linguistic transfer can be addressed. Even if it were possible to gradually diminish L1 background effects by increasing LX output, the question of which methods to use is not yet clearly understood. For example, it has been suggested that the development of reading skills would benefit from a delayed introduction to the Japanese kana and kanji as learners get accustomed to the LX input while noting that “students must be prevented from using romanization as a crutch” (Unger et al., 1993, p. 40). However, this is disputed by Packard (1990) and, more recently, by Hatasa (2002), who found that "the timing of syllabary instruction appears to make little difference in early L2 acquisition" (2002, p. 362).

Finally, findings on processing and cross-linguistic transfer may have implications for JFL textbooks. An in-depth study by Richmond (2005) can provide some context. In a paper titled “A re-evaluation of kanji textbooks for learners of Japanese as a second language”, Richmond uses four kanji textbooks as source materials. His analysis includes a detailed examination of six core assumptions on which the textbooks are based. These include assumptions about differences between L1 and LX kanji learning strategies, kanji categorisation methods, the morphology and

phonology of kanji, and the perceived necessity for LX learners to use specialised techniques such as mnemonics for effective kanji memorisation. His analysis reveals that in some areas of kanji learning, there is an unwarranted tendency to compartmentalise the kanji learning process, relying too heavily on artificial techniques that assume the LX learner is fundamentally different to the L1 reader (Richmond, 2005, p. 20). Although the sample size was small (four textbooks), the finding suggests that it may be possible to adapt or integrate more L1 pedagogical approaches into LX methodologies. In light of the findings that suggest that both orthographic background and LX exposure are significant factors in LX kanji learning, the topic of JFL textbooks and teaching materials is an area that suggests itself for further research.

### 2.5.5 Influence of behavioural factors in LX kanji learning

This section presents a brief outline of how behavioural factors can influence LX kanji learning. While factors such as motivation and self-regulation are acknowledged as meaningful in their own right in the discussion of LX kanji learning, as seen in Rose (2017), Rose and Harbon (2013), etc., they fall outside the scope of the main inquiry of this thesis, which focuses on the cognitive perspective. Nonetheless, since some reference is made to these topics in subsequent chapters, a brief outline of their impact is warranted.

There is evidence that affective factors can have an influence on LX learners in general (e.g. Okada et al., 1995; Usuki, 2000). Furthermore, studies on affective variables such as motivation in LX kanji learning suggest that it can play a pivotal role in how learners orient themselves towards kanji tasks (Kondo-Brown, 2006; Mitsuko Tanaka, 2013, 2014). For example, when documenting student's attitudes to kanji and kanji learning strategies, Mori and Shimizu (2007) identified six key attitudinal propositions. They were "kanji is fun; kanji is difficult; kanji has cultural value; kanji has future; kanji is useful; kanji learning requires special abilities" (2007, p. 483). They then correlated these propositions with student attitudes on specific learning strategies. One of the findings was that 'kanji is fun' had a statistically significant correlation with morphological

analysis strategies (2007, p. 483), indicating that students' subjective sense of enjoyment led to a stronger belief in the effectiveness of the strategy. Students' perceptions of effective kanji learning strategies may also vary according to their proficiency level, as reported by Huan (2019). The importance of motivation is supported by Nesbitt (2016), who found that using digital games in the learning process could have positive effects on the motivation of LX kanji learners (2016, p. 38). The detrimental effects of de-motivating factors, even in proficient learners, is pointed out by Rose (2010), highlighting the importance of environmental control, commitment control, and emotional control (2010, p. 237). The effects of motivation can even manifest in how users interact with digital tools such as Computer Assisted Language Learning (CALL) applications, according to Van Aacken (1999, p. 113).

The role of learner autonomy and self-regulation is another area that could have key importance to LX kanji learners, especially in light of the reality of limited classroom time and contact hours between teachers and students. Little (2009) defines learner autonomy as "the development and exercise of a capacity for detachment, critical reflection, decision making and independent action" (2009, p. 4). Usuki (2000) explicitly highlights this issue in an analysis of how to promote learner autonomy. She states, "It is asserted that most teachers of Japanese as a second language do not spend enough time on kanji teaching, with the students typically forced to try to learn much of it on their own", citing the problems of "negative feelings such as a lack of confidence, poor self-evaluation, helplessness, and worries" (2000, p. 1). Approaching the topic of kanji learning with the assumption that cognitive learning strategies could be used effectively in tandem with self-regulation, there could potentially be benefits in explicitly instructing learners so as to develop self-regulation skills. This could bring with it tangible benefits for learners. For example, Rose and Harbon (2013) examined how kanji learners regulate the task of their own learning by interviewing learners and categorizing the self-regulation techniques they used. They found that "it is at the intermediate and advanced levels where students have the biggest breakdown of commitment control" (2013, p. 103) because having progressed beyond the beginner level, it is not as clear to the learner how to proceed.

In terms of self-regulation, the use of language learning journals has gained popularity in recent times, possibly because of the flexibility it offers in including options like self-evaluation and self-reflection (e.g. Kent, 2006; Moon, 1999). The JFL series 'Marugoto' (2013), which caters to a variety of proficiency levels, has adopted similar techniques with its 'Can-Do' lists. These lists, which are adapted from CEFR[16] methodologies, are a self-reflection tool that allows the learner to gain perspective on their learning process by focusing explicitly on tangible gains they have made over time. This type of approach may yet be shown to yield benefits for the LX learner, but further research is required on how it might relate to kanji learning in particular. For example, Moritoki (2015) expresses doubts about such an approach since "Japanese language ability cannot be assessed in the same way as in European languages: Japanese is a non-Indo-European and non-Latin alphabet language, demanding much more energy and time for learners to become familiar with the script" (Moritoki et al., 2015, p. 457). Nonetheless, reflection strategies such as the "Strategy Inventory for Learning Kanji" (SILK) (Bourke, 2006) are gaining popularity. Such tools can, according to Anderson (2007), can "provide an effective and efficient reflection tool for the kanji learning process" (2007, p. 1).

## 2.6 Component analysis as a learning strategy of focus

So far, this chapter has presented a range of studies that deal with kanji processing and kanji learning from both the L1 and LX perspectives. The purpose of doing so is to understand the underlying factors that are relevant to LX kanji learning strategies and to make an informed choice on which strategy to subject to further analysis in this study. The chosen strategy should be one that appears to have significant potential to help LX learners, is based on the findings contained in the above review, but which has yet to be fully justified with empirical support, particularly in the context of a real classroom situation. This section explains why component analysis is the most suitable strategy for further investigation in this study.

[16] Common European Framework of Reference for Languages: Learning, Teaching, Assessment (2001)

One issue that emerged from the L1 processing studies reviewed in Section 2.4 was the strong support for the dual-route processing model of kanji. According to this model, both semantic and phonological information in the characters play a fundamental role in efficient kanji processing since both lexical and sub-lexical routes interact during vocalization and comprehension. This appears to be the case for both $L1^{morph}$ readers and $L1^{alpha}$ readers, with findings from Toyoda (1999; 2009), Hatta et al. (1998; 2002), etc., underscoring the crucial role that compositional features play for LX readers. With more than 60% of kanji being classified as containing a phonetic component (Tamaoka et al., 2017), it seems vital for readers to be able to efficiently extract phonological (and semantic) information from characters to be able to read kanji proficiently. Furthermore, the evidence that suggests an anatomical basis for the dual-route model could have implications for LX learners because it introduces the possibility that $L1^{morph}$ processing mechanisms can offer useful opportunities to the LX learner by adapting L1 learning materials.

In terms of issues in LX kanji learning, the studies reviewed in this chapter suggest that LX learners can experience difficulties learning kanji in part because of lingering influences from their orthographic background, particularly when it is an alphabetic background. This factor, combined with specific orthographic features of the target language, can confound the learners' difficulty in developing proficiency. For kanji learning, the studies suggest that while LX learners intuitively understand the concept of distinguishing between semantic and phonetic components in kanji, it is difficult for them to recreate an efficient parsing of those components in actual reading practice, resulting in various errors. The nature of those errors can reveal an incipient underlying mechanism that may over-rely on the use of semantic information, likely because the opaque nature of kanji character-to-sound correspondences creates barriers to the efficient extraction of the phonological information encoded within certain components.

The factors above point to the 'component analysis' learning strategy as being a suitable candidate for a more detailed investigation. Given that one of the purported effects of using this strategy is

allowing readers to perceive kanji as collections of components rather than as random collections of strokes, it is reasonable to hypothesize that learners using the strategy might develop the skills to more successfully parse both the semantic and phonological information contained in those components. If true, this could potentially mitigate the unwanted effects of cross-linguistic transfer in $L1^{alpha}$ readers and allow learners to develop a processing mechanism that simulates that of $L1^{morph}$ readers. Explicit pedagogical recommendations about the possible benefits of including component-based approaches in LX kanji learning, such as Toyoda (2000), Chikamatsu (2005) and Hagiwara (2016), further support the case for selecting component analysis as the most appropriate strategy to investigate further. However, despite the plausibility of the underlying assumptions of the strategy, to the best of my knowledge, there are few empirical studies that provide evidence about whether using the strategy does actually facilitate compositional awareness in LX readers. This study addresses this by subjecting component analysis to a more in-depth examination, aiming to understand whether its stated goals can be confirmed with empirical findings in the context of a real classroom environment.

## 2.7 Research questions

Having decided on component analysis as the most suitable candidate for a more in-depth examination, this section presents the research questions used to test the validity of its assumptions. To determine whether using component analysis produces any processing changes in learners who use it (and to understand those changes), it is essential to monitor the learners' kanji processing mechanism while they are using this strategy. If the learners show evidence of more proficient kanji decomposition over time, and if those changes can be justifiably attributable to component analysis, then it would constitute evidence in support of the strategy. To this end, materials are designed to suit the learners in a structured environment with a pre-defined and sufficient time period to monitor the changes over time. As discussed above, differences between $L1^{alpha}$ and other groups of kanji learners (such as $L1^{logo}$) means that testing should ideally concentrate on one

specific cohort. As described in Section 3.3 below, both ethical and practical considerations in this study dictate that testing must be carried out on two $L1^{alpha}$ cohorts who have different proficiency levels.

### 2.7.1 Primary research question

The primary investigation in this study involves testing whether component analysis actually produces the changes in learners that it is supposed to produce. The goal of the strategy is to facilitate intra-character awareness, which, in turn, is assumed to have tangible benefits for the learner. Whether the strategy does facilitate this awareness or not is the central question. Therefore, the primary research question is:

**RQ1: To what extent does using a component analysis kanji learning strategy facilitate learners' awareness of the compositional features of kanji characters?**

### 2.7.2 Secondary research questions

Before the primary investigation above can happen, it is vital to establish the conditions for the effective implementation of component analysis in the classroom environment. For this, designing teaching materials that accurately and faithfully enact the strategy is crucial. Beyond the design of the materials themselves, it is important to understand the range of issues that might impact the successful implementation of the materials in a real classroom situation, from how time constraints to motivation to assessment criteria, etc., might play a role. Therefore, the following secondary research question aims to answer what the conditions for the effective design and implementation of the strategy are, as follows:

**RQ1a: How can component analysis teaching materials be designed effectively for practical implementation in a classroom environment?**

Furthermore, if the use of component analysis materials does produce measurable changes, it is of vital importance to understand and explain the process in detail. This should also include feedback from the learners themselves. Therefore, two additional sub-questions are:

**RQ1b: What are the factors that influence the changes observed in kanji learners?**

**RQ1c: What issues are highlighted by kanji learners who use 'component analysis' materials?**

## 2.8 Summary

This chapter discussed a range of issues on the topics of kanji processing and learning from the perspective of L1 and LX learners. Section 2.2 gave a brief overview of the Japanese writing system and the resultant complexity of kanji characters. Section 2.3 presented a summary of established LX kanji learning strategies and highlighted some of the commonalities with L1 approaches. In Section 2.4, it was seen that studies on L1 processing provide support for a dual-route model that explains how kanji are read efficiently. According to the model, characters are processed by means of an interaction between lexical and sub-lexical routes. Both semantic and phonological information in the characters were seen to play a crucial role in efficient processing. Findings from the neurological perspective offer additional support, with some evidence that the dual-route model may have an anatomical basis, with distinct physical pathways in the brain being recruited for specific processing tasks. A range of factors that impact the processing model was also presented, including frequency, consistency, and kanji composition. These factors are relevant because studies that test their effects can provide further support for the dual-route model. In addition, understanding how these impact kanji processing could be important in methodological considerations since kanji are to be used as stimuli or source materials in this study.

In Section 2.5, it was seen that LX readers show differences from how $L1^{morph}$ readers process kanji, with LX readers exhibiting some difficulties in efficiently extracting both semantic and phonological information from kanji characters. $L1^{morph}$ readers employ a more holistic processing mechanism that extracts both semantic and visual information in kanji, resulting in harmonious cooperation of lexical and sub-lexical processing routes. The possible causes of the processing differences between cohorts were explored by examining the Orthographic Depth Hypothesis and the Direct Access Hypothesis, as well as experimental evidence from studies on cross-linguistic transfer. The pedagogical implications of these findings include recommendations that emphasize the need for LX learners to use a strategy that facilitates the development of processing both semantic and phonological information in kanji.

Section 2.6 presented the rationale behind choosing component analysis as the most suitable candidate for further study. The aim of the strategy (i.e. efficient parsing of individual kanji components) aligns with model patterns of kanji processing seen in proficient $L1^{morph}$ readers, as predicted by the dual-route model. In addition, it could have the potential to offset pernicious interference from a learner's orthographic background. Specific pedagogical recommendations regarding the use of decomposition techniques were made in several studies. However, with little empirical evidence available from real classroom situations, it is imperative that component analysis is subjected to a rigorous analysis that can explore its validity. Finally, Section 2.7 presented the primary and secondary research questions on that basis.

# 3 Research Design and Methodological Considerations

## 3.1 Introduction

The previous chapter presented a review of literature on kanji processing and learning from both the L1 and LX perspectives, with the goal of understanding kanji learning and identifying a specific LX learning strategy for further analysis. The review concluded by selecting 'component analysis' as the most appropriate strategy because it fulfilled several conditions. Firstly, the intended goal of component analysis shares important characteristics with the dual-route model, which describes kanji processing in terms of an efficient interaction of lexical and sub-lexical routes. Secondly, the findings from previous studies suggest that component analysis would offer kanji learners potential advantages in terms of mitigating unwanted cross-linguistic transfer effects, particularly in the case of learners from incongruent orthographic backgrounds, like $L1^{alpha}$ learners. Finally, while the findings from previous studies indicate that component analysis would offer potential benefits to kanji learners, the strategy has yet to be fully validated with empirical support, particularly in the context of real classrooms.

This chapter presents a discussion of how to proceed with the investigation of component analysis based on the research questions, detailing the research paradigm and methodological considerations that shape the design and execution of the study. Section 3.2 begins with a brief summary of how qualitative and quantitative approaches have been used in kanji research to date and explains why a mixed methods approach is the most suitable framework to answer the research questions in this study. Section 3.3 discusses the methodological considerations that influence the design and execution of the study. Section 3.4 describes the research procedure, a two-phase mixed methods approach with several sets of data collection in each phase. Finally, Section 3.5 outlines some issues related to research integrity and how this study addresses those issues.

## 3.2 Research framework

### 3.2.1 Why mixed methods?

Teddlie and Tashakkori (2009) state that "Mixed methods data analysis involves the integration of statistical and thematic data analytic techniques" (2009, p. 8), while Johnson and Onwuegbuzie (2004) define mixed methods as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (2004, p. 17). The fundamental principle is that "researchers should collect multiple data using different strategies, approaches, and methods in such a way that the resulting mixture or combination is likely to result in complementary strengths and nonoverlapping weaknesses" (Johnson & Turner, 2003, p. 315). In considering what kind of research paradigm is most appropriate for answering the research questions, it is important to consider how different approaches in kanji research have yielded results in the past. Quantitative approaches have been used extensively to isolate and investigate relationships between specific variables. For example, experimental designs have used kanji as stimuli to explore areas such as memory (Bai & Iwasaki, 2004), cognition (Nakagawa, 1994; Verdonschot et al., 2010), and language dysfunction (Fushimi et al., 2009; Ozeki et al., 2018; Seki et al., 2004). A typical example is something like Niermeyer et al. (2018), wherein electrodes were attached to subjects' heads while they were visually presented with kanji on a monitor. Electrical impulses were recorded and used to draw detailed conclusions about processing phenomena in different parts of the brain. These kinds of methodologies are extremely useful when striving to establish how a particular variable is affected by a controlled experimental intervention at a specific point in time. They often involve the use of carefully calibrated equipment in controlled experimental conditions. An advantage of this is that the rigorous statistical analyses involved serve to bolster the findings and can justify generalizations beyond the confines of the laboratory. This, in turn, can establish well-defined explanations of detailed aspects of kanji characters. One possible drawback to these approaches is that they generally require rigorous experimental conditions and tend to have a rather narrow focus.

On the other hand, qualitative approaches have been used to provide detailed analyses on a range of kanji topics like affective factors (Kondo-Brown, 2006; Mitsuko Tanaka, 2014), the nature of kanji writing errors (Hatta et al., 1998; 2002; Ivarsson, 2018), the influence of learning strategies (Gamage, 2003; Rose, 2013; T. Yamashita & Hung, 2016), the role of context in kanji learning (Mori, 2003; Robertson, 2015), etc. These approaches offer the researcher a valuable opportunity to understand in detail some of the internal processes that learners undergo over the course of their learning. A variety of data, such as from interviews, surveys, focus groups, etc., can offer insights into how the learner perceives the learning process and how that perception might change during the process. The highly complex nature of kanji means that proficiency can only be acquired over an extended period of time. Qualitative approaches also offer the researcher specific advantages because they have the ability to examine longer periods rather than focusing on a snapshot of one specific moment in the process. In addition, data from a range of sources, such as writing samples, classroom observations, etc., can be integrated into a longitudinal contextual analysis that can provide a broader perspective than would be possible with a quantitative-only analysis. As noted by Mason (1996), "the qualitative habit of intimately connecting context with explanation means that qualitative research is capable of producing very well-founded cross-contextual generalities" (1996, p. 1). Possible drawbacks to a qualitative approach might be issues with sample size, generalizability, or difficulty interpreting the precise interplay of variables that cannot be controlled as strictly as in experimental setups.

The primary research question, RQ1 (*To what extent does using a component analysis kanji learning strategy facilitate learners' awareness of the compositional features of kanji characters?*), seeks to answer whether the use of component analysis produces changes in processing by kanji learners using it. Accurately testing the change in processing by learners is a fundamental aspect of answering the research question. Quantitative data can be used at two different time points in the learning process to establish precise markers that allow for an accurate comparison between the points and between groups. As with the experimental setups mentioned above, using kanji as stimuli in a controlled setting is an ideal option for carrying this out. For this purpose, this study

will use eye-tracking technology to measure changes in cognitive load for specific areas of kanji characters, as is explained in Section 6.4. In conjunction with this data, rates of kanji writing errors can be used as further markers to identify changes in cognition between the time points.

In contrast, the sub-question RQ1b (*What are the factors that influence the changes observed in kanji learners?*) aims to answer what the nature of the observed changes is and what the possible explanations are. This requires a qualitative approach that can take into account a range of possible causal factors and incorporate them into a contextual analysis that can offer possible conclusions. For this purpose, samples of kanji writing errors are analysed in conjunction with the visualization of data from the eye-tracking samples, as shown in Section 6.5. This also applies to RQ1c (*What issues are highlighted by kanji learners who use 'component analysis' materials?*), which aims to identify issues experienced by the learners who used the teaching materials themselves. Again, using a qualitative approach that can incorporate the subjective perceptions of the learners is necessary.

The secondary research question RQ1a (*How can component analysis teaching materials be designed effectively for practical implementation in a classroom environment?)* aims to answer how to design and implement component analysis in a classroom environment. For this, a qualitative approach is again appropriate because establishing the conditions will require an analysis that can simultaneously consider factors such as contact hours with students, textbooks, assessments, motivation, etc. Only by considering a range of factors and the interplay between them can the design and implementation be carried out successfully.

The inclusion of quantitative and qualitative data sets proposed above indicates that a mixed methods approach is most appropriate for this study, as it requires a framework that has the ability to accurately quantify the occurrence of specific changes in kanji processing between two discrete

time points, to analyse the process and nature of those changes in detail, and to do so having first fully considered the context in which they happened. In terms of its application to this study, the design and implementation of teaching materials for use in a natural setting will require qualitative data that considers a range of practical factors. Quantitative data can then be used to accurately measure detailed changes in how the kanji processing of the learners differs between two time points, i.e. before and after the use of component analysis. Having quantified the changes, understanding the nature of these changes will require a more intuitive approach that is again driven by qualitative data, exploring how the process might have changed over time and what factors could have produced or influenced it.

### 3.2.2 Exploratory Design Model

In terms of a timeline, it is clear that the secondary research question RQ1a must be answered first since it will inform the design and implementation of materials that use component analysis in the classroom. Having completed the design, RQ1 and the sub-questions RQ1b and RQ1c can then be answered. This operation is necessarily a two-step chronological process, wherein the findings from the first step (PHASE 1) inform the design of something used in the second step (PHASE 2). Therefore, this study uses an adaptation of an Exploratory Design Model (Creswell & Plano Clark, 2007). This is a two-phase mixed methods model that begins with a qualitative phase in order to explore the conditions surrounding a phenomenon (Creswell & Plano Clark, 2007, p. 77). This type of model seeks "to use the results from one method to help develop or inform the other method, where development is broadly construed to include sampling and implementation" (Greene et al., 1989, p. 250). This is a particularly appropriate model for this study because the qualitative data from PHASE 1 is a crucial element in designing teaching materials for implementation in PHASE 2, which is characterized by the inclusion of quantitative data. Figure 3 below shows a visual representation of a typical timeline for an Exploratory Design model (adapted from Creswell & Plano Clark, 2007, p76).

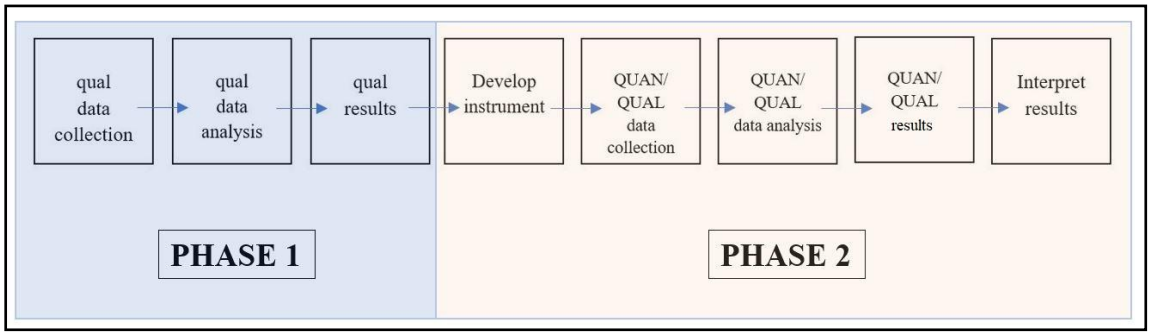



*Figure 3: Adaptation of Exploratory Design timeline (Creswell & Plano Clark, 2007, p. 76)*

PHASE 1 involves the collection of qualitative data that is used to answer RQ1a and establish the conditions for the effective design and implementation of component analysis in the classroom. PHASE 2 involves the design and implementation of materials, the collection of quantitative and qualitative data to answer RQ1 by monitoring whether processing changes have happened in learners using component analysis, and the collection of qualitative data to answer RQ1b and RQ1c and explain the nature of the changes observed and the subjective experiences of the learners themselves.

## 3.3 Methodological considerations

Having identified the appropriate research paradigm and a suitable framework to answer the research questions, what remains is to construct a methodology that allows for appropriate data collection within that framework. This section considers the two phases in chronological order, detailing the rationale for choosing the specific data collection methods described.

### 3.3.1 PHASE 1

Before using component analysis, it is of critical importance to understand how to do so effectively and to have a precise awareness of what kind of factors might impact its use in a genuine classroom environment. There are two issues that must be considered – design and implementation. The design of the teaching materials is important because they must represent a faithful and accurate

enactment of the component analysis strategy if the findings in PHASE 2 are to be attributable to their influence. The implementation is important because, in a university classroom environment, there are a variety of external factors that could impact the successful use of component analysis materials, such as assessment formats, student motivation, homework, time considerations, etc. PHASE 1 can address these issues by answering Research Question 1a (*How can component analysis teaching materials be designed effectively for practical implementation in a classroom environment?*)

To understand the factors that might influence the implementation of component analysis, one practical option is to collect data by means of a survey of professional JFL teachers. Survey responses could offer insights into a range of pedagogical issues such as teaching strategies, teaching materials, classroom environments, and specific information about how kanji teaching might be impacted by the policies of academic institutions. This kind of pragmatic information could be very useful when designing lesson plans or adapting the module details to integrate component analysis without compromising the learning outcomes. There may also be opportunities to use or adapt specific kanji teaching methods suggested by the teachers. Therefore, from both a design and implementation point of view, a survey of JFL teachers with a contextual qualitative analysis is included.

An examination of how component analysis is currently used in JFL textbooks could also be useful in deciding how to adhere to module outcomes while teaching in PHASE 2 correctly. Such an analysis could reveal biases in specific textbooks or generate potentially useful insights about kanji teaching and the role of component analysis in current trends of kanji pedagogy. As with a survey of JFL teachers, there may be opportunities to use or adapt specific exercise types in the design of new materials. Another point to consider is that an analysis of JFL textbooks can also provide a useful comparative reference that grounds the design of new materials within acceptable parameters. To stray too far from standard practices seen in current JFL textbooks could be

considered to be a radical and irresponsible departure from accepted pedagogical norms, particularly when there are consequences for the participants. An analysis of JFL textbooks, therefore, is also useful on ethical grounds.

One more area of potential is the possibility of using L1 kanji teaching methodologies or materials as a point of reference in designing and implementing LX materials. Given the support in the literature for the dual-route processing model (as described in Chapter 2), there may be opportunities to adapt domestic kanji teaching materials or pedagogical strategies for use in the LX classroom. To explore this option further, this study includes an analysis of kanji teaching materials that are used in the domestic Japanese education system. The analysis is based on field notes from classroom observation sessions in Japanese elementary schools and from informal interviews with the teachers of those classes.

### 3.3.2 PHASE 2

The first consideration in this phase is how the selection of participants will influence the methodology. University regulations on research integrity and ethical standards provided very specific parameters in which this study can operate. As such, all participants taking the same module must receive identical language instruction. It is not possible, for example, to divide a class in half and use different teaching methods in each group. In practice, it is also not possible to recruit two different classes of the same proficiency because of limited student numbers. Therefore, based on availability and on ethical considerations, the most practical option for this study was to recruit two groups of kanji learners who have different proficiency levels (ab-initio and lower-intermediate) and to design the methodology accordingly. All subsequent aspects of the study were designed to accommodate the practical circumstances of using these two groups.

The overall purpose of PHASE 2 is to answer Research Question 1 and the sub-questions RQ1b and RQ1c. A crucial aspect of answering RQ1 is deciding how to accurately monitor the kanji processing of participants over the course of the study. As discussed above, a mixed methods approach is preferable. One reasonable option that has precedence in the literature is to use eye-tracking technology. Eye-tracking has been widely used as a way to measure cognitive load in a variety of contexts. For example, Dalmaso et al. (2017) found that the difficulty of a mental task had a direct effect on saccadic motion, concluding that "microsaccades cannot be merely confined to oculomotor responses supporting vision, but rather they might also be considered as a multifaceted index of cognitive processing" (2017, p. 8). This is corroborated by Krzysztof et al. (2018), who found a larger micro-saccadic size for more difficult tasks and concluded that "change in pupil diameter and microsaccade magnitude appear to adequately discriminate task difficulty, and hence cognitive load" (2018, p. 1). Eye-tracking has also been used specifically in research on $L1^{morph}$ readers of Japanese. For example, it has been variously used to test developmental reading skills (Jincho et al., 2014), to understand how word length and composition influence processing (White et al., 2012), or to examine the role of interword spacing when reading Japanese (Sainio et al., 2007). Studies such as these offer a useful reference in designing methods that can monitor the processing of LX kanji readers, as it is possible to adapt these methods so that the processing of LX kanji readers can be monitored on the sub-character level by measuring cognitive load when focussed on specific components in kanji.

To understand the nature of any changes observed in the eye-tracking data and answer Research Question 1b (*What are the factors that influence the changes observed in kanji learners?*), an analysis of kanji writing errors was included. This method has variously been used by Hatta et al. (1998, 2002), Ivarrson (2018), and Li (2017) to understand the characteristics of kanji writing errors and to relate those errors to the underlying processing mechanism that produced them. For example, when Hatta et al. (1998) compared $L1^{morph}$ and $L1^{alpha}$ kanji errors, they found noticeable differences. The $L1^{morph}$ group produced mostly phonological errors, whereas the $L1^{alpha}$ group produced mainly Non-Kanji errors, i.e. written attempts that do not correspond to an existing kanji

character (1998, p. 303). The authors speculate that the large number of homophonic kanji in the Japanese language may be responsible for the high phonological error rates among L1$^{morph}$ kanji users. In Hatta et al. (2002), three groups were compared: L1$^{morph}$ children, L1$^{morph}$ adults, and L1$^{alpha}$ adults. The L1$^{morph}$ adults again made mostly phonological errors, corroborating the findings from previous studies, while the L1$^{morph}$ children made mostly orthographic errors. Again, the L1$^{alpha}$ learners made mostly Non-Kanji errors (2002, p. 157). In a comparison of L1$^{morph}$ children and level-matched L1$^{alpha}$ adults by Ivarrson (2018), it was found that while both groups tended to make Non-Kanji errors, the L1$^{morph}$ children had a more accurate awareness of phonology than the L1$^{alpha}$ adult learners (2018, p. 171). These findings seem to show that kanji learning, at least for L1, begins from an incipient processing mechanism that favours semantic processing. Orthographic representations must then be correctly stored in the memory, followed by a progression to the development of accurate phonological processing as the mechanism becomes more sophisticated. Studies such as these show that writing error analysis is a practical method that can be implemented in classrooms and one that offers the potential to gain valuable insights into the qualitative aspects of the errors. Furthermore, since the method relates writing errors to the processing mechanism that produced them, it can be used in tandem with eye-tracking to offer a broader perspective on changes in learners' processing.

Finally, Research Question 1c seeks to answer what the subjective experiences of the learners are. For any learning strategy to be effective, it must have value from the subjective point of the learner. It is important to conduct a post-test feedback survey that seeks to understand the strengths and weaknesses of the strategy and materials from the perspective of the learners who used them. A standard feedback survey is a practical tool to elicit responses from participants and understand how learners engaged with the materials. The responses can help identify areas that learners found useful, as well as highlighting aspects that can be improved in future iterations of the materials or for future research. This is important because it can point to specific areas upon which the successful use of component analysis might be contingent.

One final consideration is the argument that developmental factors might influence the findings in this phase since some studies discussed in Chapter 2 (e.g. Chikamatsu, 2006; Hamada & Koda, 2008; Liu et al., 2006) suggest that exposure to the target language can be a factor in reducing cross-linguistic transfer. The cohorts used in this study are ab-initio learners with no previous kanji knowledge and lower-intermediate learners with approximately 1-2 years of kanji learning experience. Since one group of learners has little or no prior kanji learning, it could be argued that any observed changes in their kanji processing could be attributable to exposure to the target language over the course of the testing period rather than a learning strategy being a causal factor. This line of argument highlights an ever-present difficulty with conducting any kind of longitudinal research on kanji. As mentioned in Chapter 6 below, this study tries to address that argument by including a comparison of pre-semester and post-semester measurements for both groups. By using the pre-semester measurements of the lower-intermediate group as a reference point, it is possible to draw reasonable conclusions about the magnitude of possible effects from target language exposure in the ab-initio group. In doing so, this study attempts to reduce the error margin that can be a challenge in longitudinal kanji research.

## 3.4 Research procedure

This study was designed with two sequential phases. The purpose of PHASE 1 was to answer RQ1a, i.e. to establish what the conditions are for the effective design and implementation of component analysis in a classroom environment. The purpose of PHASE 2 was to design and implement those materials, to collect data that allows for accurate monitoring of kanji processing by the participants, and to analyse any observed changes in an attempt to understand the process and causal factors. Given the methodological considerations outlined above, the research procedure for both phases is shown below.

### 3.4.1 PHASE 1

The three data collection stages of PHASE 1 are shown below.

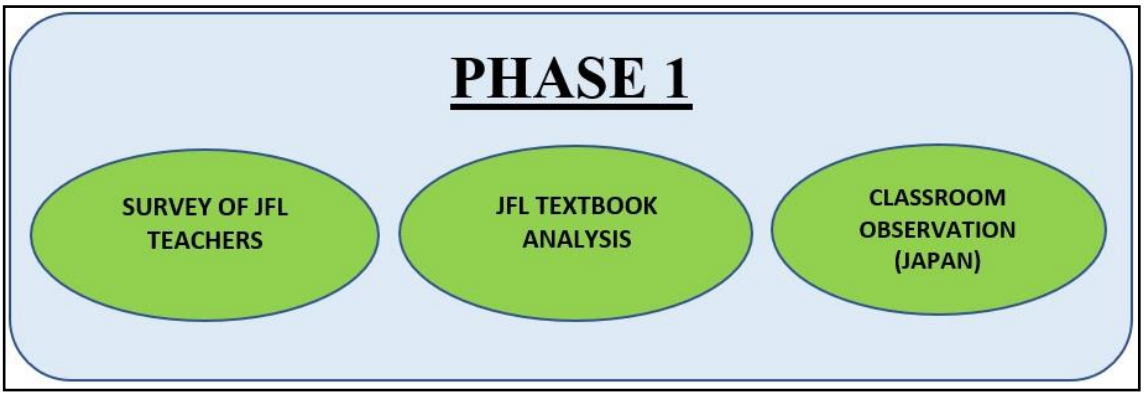



*Figure 4: Data collection stages within PHASE 1*

During PHASE 1, three types of data were collected:

**(1)** A survey of JFL instructors was used to analyse the practical issues faced by teachers in the classroom. It aimed to provide context that can inform the design and implementation of component analysis in PHASE 2.

**(2)** An analysis of JFL textbooks was carried out to understand the role of component analysis in JFL teaching materials and to provide a reference point for its design and implementation in PHASE 2.

**(3)** Classroom observation in Japan was used to gather data on teaching materials and strategies used to teach kanji in the domestic Japanese education system. The aim was to understand some of the differences between L1 and LX approaches and to assess whether some L1 strategies could be adapted for the LX environment.

### 3.4.2 PHASE 2

The findings from the three stages of PHASE 1 informed the design of original teaching materials, which aimed to enact component analysis in an authentic manner during PHASE 2. The teaching materials are called 'Intra-Character Awareness Exercises' (ICA) in this study. See Section 6.3 below for a detailed explanation of Intra-Character Awareness Exercises. The stages of PHASE 2 are shown below.

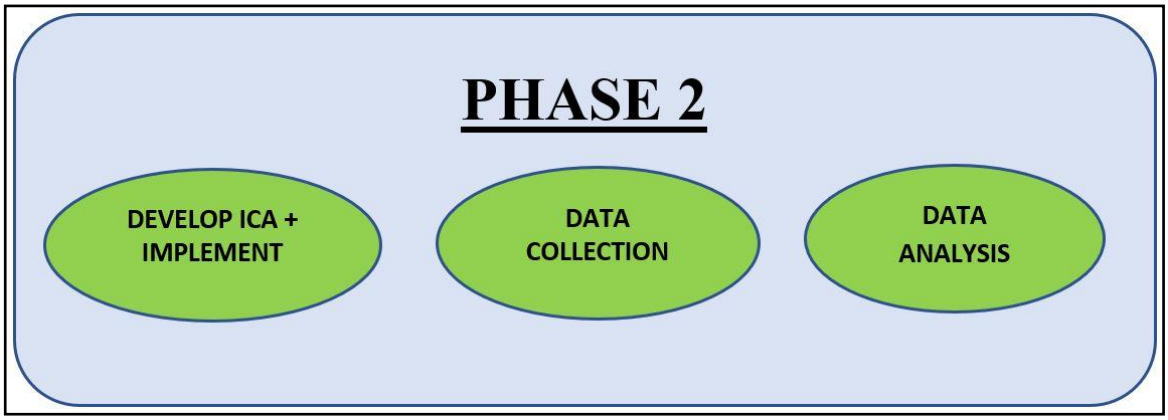



*Figure 5: Stages within PHASE 2*

There were three discrete aspects in PHASE 2, as follows:

**(1)** Design and implementation of the Intra Character Awareness teaching materials.

**(2)** Data collection, consisting of eye-tracking data, writing error analysis, and a student feedback survey.

**(3)** Data analysis of the three data sets.

See Appendix L for a graphical timeline of the entire research process.

## 3.5 Research integrity

There are several stages that involved collecting data from human participants. This study obtained approval from the Research Ethics Committee at Dublin City University (Reference Number DCUREC/167). Particular attention was paid to ensure fairness amongst the students in the cohorts by ensuring that all students received identical instruction and by clearly explaining that non-participation would in no way compromise their learning process. See Appendices A, B, and C for copies of the letter of approval from the Committee, as well as copies of the Plain Language Statement and Informed Consent form, which were furnished to all participants prior to commencement of the study.

# 4 PHASE 1: Methodology

This chapter presents the methodology of PHASE 1 of the study, consisting of three separate stages of data collection. The findings and discussion are presented in subsequent chapters.

## 4.1 Survey of JFL teachers

### 4.1.1 Method

An online survey of JFL teachers was used to collect a broad base of data relating to practical kanji pedagogy. The survey was designed to consist primarily of open-ended questions which collected data about the teachers themselves, the context in which they teach Japanese, and their opinions and attitudes on a broad range of practical kanji teaching challenges they face while working in educational institutions. Specifically, the content of the questions was divided thematically to encompass teaching environment, teaching materials, teaching and learning strategies, teacher attitudes, and a general section that afforded teachers the opportunity to offer opinions about the key challenges they deemed important. The goal of the survey was to establish an accurate overview of practical issues that JFL teachers face, as well as understanding current standard practices of teaching kanji in authentic classroom situations, from 2nd level to 3rd level education institutions. The survey sections are listed below. See Appendix D for a detailed breakdown of the questions used in each section of the survey.

*Section A - Teaching environment*: This section attempted to ascertain the context in which the respondent was teaching kanji. It contained questions relating to academic institutions, class size, cohort details, module learning outcomes, and kanji proficiency assessment strategies.

*Section B - Teaching materials*: This section aimed to establish an overview of the kinds of materials used by instructors when teaching kanji. It included questions about textbook use, evaluation of textbooks, types of supplementary teaching materials used, and use of digital technologies such as software and apps (where applicable).

*Section C - Teaching methods*: This section included questions that sought to catalogue the kinds of kanji teaching strategies used by teachers or strategies recommended by them to their students. Question topics ranged from time spent on kanji in class, to homework activities, to specific questions about whether radicals or component analysis was a feature of their instruction.

*Section D - Teacher attitudes*: This section used a series of questions to document teachers' opinions and perceptions about a variety of kanji-related topics such as the importance of reading and writing, student motivation, teacher motivation, and perceived difficulties in teaching or learning kanji.

*Section E – General*: This section provided teachers with an opportunity to offer their own opinions on which aspects of kanji teaching and learning they believe are particularly important. Open-ended questions allowed teachers to expand on previous answers and indicate what they considered to be the main challenges faced by both teachers and students.

### 4.1.2 Participants

Professionally employed JFL teachers in 2nd level and 3rd level institutions from anywhere in the world were recruited through a network of teachers, with the survey being distributed by group email via the JLTI (Japanese Language Teachers of Ireland) and by the Japan Foundation Senior Japanese Language Advisor to the Post Primary Language Initiative (Ministry of Education, Ireland). Participation was anonymous, with no remuneration or reward offered for taking part. A total of 42 respondents completed the survey. Of the 42, a total of 36 respondents indicated in what country they teach Japanese, with 14 from the UK, 11 from Ireland, 5 from New Zealand, 4 from Japan, 1 from the US, and 1 from Sweden. The teachers were a mixture of native Japanese speakers (29 respondents), non-native Japanese speakers (12 respondents), and one bilingual teacher. The majority of the teachers taught in either a university context (17 respondents) or a second-level context (16 respondents). The remainder taught in a mixture of contexts such as teaching private lessons, evening classes, and teaching in private language schools.

### 4.1.3 Analytical framework

The online survey data was analysed in Nvivo 12 Pro (QSR International) using the 6-step thematic analysis process detailed in Braun & Clarke (2006, 2013). This is a standard analytical process in which three types of manual coding are generated sequentially as the researcher makes passes at the data. This analysis framework was selected because the survey generated data on a broad range of topics and included many open-ended questions that allowed respondents to answer in their own words. The framework allows the researcher to aggregate the general themes of all respondents in a systematic way. See Appendix K for a sample of manual coding generated in Nvivo 12 Pro. The framework recommended in Braun & Clarke is shown below.

*Table 1: Six-step thematic analysis framework (Braun & Clarke, 2006;2013)*

| | |
|---|---|
| Step 1: | Become familiar with the data |
| Step 2: | Generate initial codes (**Open coding**) |
| Step 3: | Search for themes (**Axial Coding**) |
| Step 4: | Review themes |
| Step 5: | Define themes (**Selective Coding**) |
| Step 6: | Write-up |

Questions that used a Likert-Scale response were first sorted using Microsoft Excel and then imported to Nvivo 12 Pro to be integrated into appropriate data nodes generated in the coding process described above. Since there was a considerable amount of thematic overlap from the respondents across the sections, the findings in Chapter 5 are presented in an aggregated form rather than isolating each individual section. For example, several teachers highlighted the issue of time constraints multiple times across different sections. Rather than analysing each instance of this separately under one of the five specific topics above, it was integrated as an overall theme that runs through the respondents' opinions. Accordingly, the most prevalent themes relating to kanji teaching are presented with sample quotations wherever a particular comment was deemed to be insightful or significant in the context of the study.

## 4.2 Analysis of JFL textbooks

### 4.2.1 Overview

This section describes how an analysis of 23 standard JFL textbooks was conducted to understand how component analysis is currently employed in JFL publications. The analysis focused on establishing how broad is the range of JFL textbooks that do actually use component analysis, whether as an explanatory reference or as a productive exercise. It was anticipated that this kind of data could be useful in the design of the teaching materials in PHASE 2, as well as providing a reference point on pedagogical norms in JFL textbooks.

### 4.2.2 Source materials

A total of 23 JFL textbooks were selected for analysis. The selection process was informed by factors such as findings from the survey of JFL teachers described above, informal reports from JFL teachers, and the inclusion of standard JFL textbooks that have been used in university courses in Ireland. The final list of source materials contains a variety of textbook types and includes well-known standard JFL textbook series such as ‘Genki’ (Banno, Yutaka, & Yoko, 1999), ‘Marugoto’ (Kijima et al., 2013), ‘Minna no nihongo’ (Ogawa, 1998), as well as several other commonly used publications. See Appendix E for a complete list of the JFL textbooks used as source materials for the analysis described in this section.

### 4.2.3 Analysis method

The analysis method centred on comparing categories of kanji references and exercises across the source materials, based on whether they focus on components, single characters, or compound words. Artificial categories (called ‘kanji iterations’) were assigned to a broad range of kanji references and exercises in the materials. The presence or absence of each of these categories in a textbook was then documented, allowing for a comparison of the relative use of each one. The justification for using this approach is that textbooks generally follow a formula that involves repeating exercise types in each chapter rather than offering a wide variety of exercise types in

small numbers. For this reason, rather than categorizing all individual references and exercises within all the textbooks, it was sufficient to identify whether one instance was present or absent in a textbook. While previous methods of analysing JFL textbooks have examined aspects such as the underlying assumptions of the strategies themselves (Richmond, 2005), or the role of input in JFL textbooks (Didi-Ogren & Jr, 2008), this method allows for a simple comparison between the types of kanji references and exercises used.

Four passes were made at the source materials. In Pass 1, any explanatory kanji reference or any productive kanji exercise was identified and documented as a 'kanji iteration'. For the purpose of this analysis, the term kanji iteration is intended to refer to any instance in a textbook that can be reasonably considered to be an explanation of something related to kanji or to be a task or exercise that tests some kind of kanji-related knowledge. In Pass 2, these kanji iterations were categorized into the three general classifications of 'Component', 'Single-Character', or 'Compound', depending on how the iteration was framed. This classification reflects the common trend in JFL materials of presenting target kanji as single characters, in compound words, or sometimes as components. In Pass 3, those three categories above were further divided into the sub-categories of 'Meaning' (an iteration involving the meaning or semantic content), 'Pronunciation' (an iteration involving KUN or ON readings or pronunciations), and 'Writing' (an iteration involving writing, stroke order, or compositional features). As above, the classification is based on the tendencies of JFL materials to present target kanji with particular kinds of information. In Pass 4, a final subcategory of 'Reference' or 'Exercise' was assigned to each kanji iteration. For this pass, 'Reference' refers to an explanatory iteration that provides information but does not require the reader to generate an answer to a posed problem. The term 'Exercise' refers to an iteration in which the reader is explicitly asked to generate a solution to a specific task or problem. In total, the four passes resulted in 18 categories of kanji iterations. Table 2 shows a breakdown of these kanji iterations into their categories, as well as definitions or typical examples seen in the source materials.

*Table 2: 18 Categories of kanji iterations in JFL textbooks*

| Pass 2 | Pass 3 | Pass 4 | Definition or Example of Iterations |
|---|---|---|---|
| Component | Meaning | Reference | "卜 – this is a picture of a divining rod" (Remembering The Kanji 1, p32) |
| Component | Meaning | Exercise | Any exercise testing the meaning of a component |
| Component | Pronunciation | Reference | Any reference to the pronunciation of an individual component |
| Component | Pronunciation | Exercise | "ta + chikara = otoko" (Basic Kanji 1, p45) |
| Component | Writing | Reference | Explanation of component - "Games using radicals" (Basic Kanji 1, 116) |
| Component | Writing | Exercise | "Combine top and bottom and make kanji" (Basic Kanji 1, p116) |
| Single-Character | Meaning | Reference | "Opposite Actions: 起　寝" (Basic Kanji 2, p11) |
| Single-Character | Meaning | Exercise | Exercise testing the meaning of a kanji character (Basic Kanji 2, p13) |
| Single-Character | Pronunciation | Reference | Any provided readings of a single-character kanji |
| Single-Character | Pronunciation | Exercise | "What are the readings of 外"? (Genki 2, p293) |
| Single-Character | Writing | Reference | Character stroke order guide (i.e. Japanese for Busy People 2, p232) |
| Single-Character | Writing | Exercise | Character practice boxes (i.e. Japanese for Busy People 2, p232) |
| Compound | Meaning | Reference | Any provided definition of a compound word written in kanji |
| Compound | Meaning | Exercise | Any exercise testing the meaning of a compound |
| Compound | Pronunciation | Reference | Target 本, reading of the compound 山本 (Genki 1, p266) |
| Compound | Pronunciation | Exercise | Read aloud 本社 (Marugoto Shokyu 1 Rikai p121) |
| Compound | Writing | Reference | Provision of compound kanji word (Marugoto Shokyu 2 Rikai, p63) |
| Compound | Writing | Exercise | "Write the kanji for やきにく" (Basic Kanji 2, p151) |

To gain an understanding of the range of textbooks that use a particular iteration relative to others, the approach taken was to assign a binary code of '1' or '0' to each iteration according to whether it occurred or not anywhere in a given textbook. Any iteration contained in a textbook was considered to be evidence of that specific textbook using that particular iteration as part of its core strategy. Even a single instance of an iteration was considered as valid use for the purpose of this analysis. For example, when an exercise required the learner to produce a written representation of an individual component, the textbook in which it appeared was assigned a '1' for the category 'Component-Writing-Exercise'. If that same textbook contained no exercises in which the task was to produce the pronunciation of a component, the category 'Component-Pronunciation-Exercise' was assigned a '0'. Another common example is where a textbook provides the meaning of a compound word but does not follow this with any productive exercises using that compound. In that case, the textbook in which it appears was assigned a '1' for the category 'Compound-

Meaning-Reference' and a '0' for the category 'Compound-Meaning-Exercise' (assuming there were no other iterations of that type). This method offers a way to examine the range of textbooks that use a particular method by calculating the percentage of textbooks that use a specific kanji iteration. Figure 6 below shows how the source materials were assigned binary codes in order to generate statistical information about the iterations contained therein.

| | TextbookName | componentmeaningreference | componentmeaningexercise | componentpronunciationreference | componentpronunciationexercise | componentwritingreference | componentwritingexercise | charactermeaningreference | charactermeaningexercise | characterpronunciationreference |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kanji Look and Learn Text/W... | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| 2 | Genki 1 textbook | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 3 | Marugoto A1 Rikai 入門 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 4 | Marugoto A2 Rikai 初級1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 5 | Marugoto A2 Rikai 初級2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 6 | Basic Kanji Volume 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | Basic Kanji Volume 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 8 | Japanese for Busy People 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 9 | Nihongo Kantan | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 10 | Kanji from Zero 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 11 | Remembering the Kanji | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 12 | Kanji in Context workbook | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 13 | Minna no nihongo 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 14 | Minna no nihongo - Kanji | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 15 | A guide to writing kanji and k... | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 16 | ryuugakusei no tame no kanji | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 17 | Nakama | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 18 | Practical Kanji | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 19 | Nihongo challenge kanji N4N5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 20 | Tobira | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | Japanese Kanji for Beginners:... | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| 22 | Let's Learn Kanji | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | J-Bridge | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | | | | | | | | | | |
| 25 | | | | | | | | | | |

*Figure 6: Samples of binary data generated from JFL textbooks*

The above method of categorization produced binary data for each of the 18 categories of kanji iterations in the 23 JFL textbooks. The table was imported to IBM SPSS Statistics 24, and each category was labelled as binary numeric data, with '0' defined as the absence of an iteration category in the textbook and '1' defined as the presence of an iteration category in the textbook. This data was used to generate frequency statistics based on the percentage of textbooks that use each of the 18 categories. Two sets of frequency statistics were generated. In the first set, the iterations 'Reference' and 'Exercise' were combined, producing frequency information on the level of 'Component', 'Single-Character', and 'Compound', each with the subcategories of 'Meaning', 'Pronunciation', and 'Writing'. This set of statistics provides an overview of the categories without differentiating between the iteration as an explanatory reference or as a productive exercise. The second set of frequency statistics refers only to the 'Exercise' categories, producing statistics from all the nine categories that require the learner to complete a task. This allows for a comparison between the overall use of an iteration and a more detailed examination of how often a productive exercise is used within that category. The findings are presented and discussed in Chapter 5.

## 4.3 Classroom observation (Japan)

### 4.3.1 Overview

As discussed in Chapter 3, it was decided to collect data on kanji teaching from domestic Japanese classrooms to assess whether it was possible to adapt specific L1 strategies or materials for use in the LX classroom. The sessions also provided an opportunity to gauge how L1 and LX methodologies are respectively supported by evidence from the studies discussed in Chapter 2.

### 4.3.2 Participants

Two classes from Konan Elementary School (Toyama Prefecture, Japan) were observed. One was a class of 4th-grade elementary school students (age ten approximately), and another was a class of 6th-grade elementary school students (age 12 approximately). All participants were $L1^{morph}$ (native Japanese) children. As the participants were under 18, full approval to engage with the school for the purpose of classroom observation was granted by Dublin City University. Following this, a series of direct communications with the education board responsible for the elementary school took place. Having obtained permission from the education board, the classes to be observed were decided. Prior to both classes, a meeting took place with the school principal, the teacher of the class, and the principal investigator. In all communications, the purpose and nature of the proposed research were explained, and permission to observe the classes was received.

### 4.3.3 Method

Two 40-minute classes were observed in an elementary school in Japan. In both classes, one of the aims of the lesson was to generate interest in kanji learning by drawing attention to interesting details about the characters. This was to be reinforced with a variety of reading and writing exercises, with a combination of textbook materials and supplementary materials provided by the teachers. During the classes, field notes were taken on how the teachers presented the topic and also on the specific types of exercises that the students were given. After each class, an informal interview took place in which the teachers provided samples of the teaching materials used during

the class and in preparation for the class. The teachers explained their general approach to teaching kanji in elementary school and how it fits with the standardized curriculum as prescribed by the Ministry of Education in Japan.

Analysis of the observation sessions was done by categorizing the details of specific kanji exercises contained within the materials provided by the teachers and documenting the teaching methods used in class. This was correlated with field notes taken during the classroom observation sessions to produce an overview that considers the teaching materials, the teaching methods, and more general information relating to kanji learning in the Japanese education system. This was then used in conjunction with findings from the survey of JFL teachers and JFL textbook analysis when considering the design and implementation of new component analysis materials. The key findings and discussion of the classroom observation sessions are presented in Chapter 5, along with several samples of the teaching materials that were provided by the teachers.

# 5 PHASE 1: Findings and Discussion

## 5.1 Introduction

This chapter presents the findings from the three stages of data collection carried out in PHASE 1 and a detailed discussion of those findings. The purpose of collecting and analysing these data sets was to answer Research Question 1a *(How can component analysis teaching materials be designed effectively for practical implementation in a classroom environment*). Section 5.2 presents and discusses the findings from a survey of JFL teachers. Section 5.3 follows this with the findings and discussion arising from an analysis of 23 JFL textbooks. Section 5.4 provides a summary and discussion relating to field notes and materials collected during two classroom observation sessions carried out in domestic Japanese classrooms. Finally, Section 5.5 concludes with an overview of how the findings from PHASE 1 taken as a whole can be used to inform the design and implementation of component analysis materials in PHASE 2 of the study.

## 5.2 Survey of JFL teachers

As outlined in Chapter 4, the questions about kanji learning in this survey were structured into five sections, covering areas relating to teaching environment, teaching materials, teaching methods, teacher attitudes, and general feedback. The thematic analysis showed that the respondents highlighted several issues related to kanji teaching and learning. These themes were divided into three broad categories. They are (1) Issues for teachers, (2) Perceived issues for students, and (3) Evaluation of textbooks. These are each presented and discussed in a separate subsection below, with selected quotations from the respondents included where relevant.

### 5.2.1 Issues for JFL teachers

Responses about the difficulties of teaching kanji were seen to encompass five broad categories. Figure 7 below shows the dominant themes that emerged from respondents and the number of

coded references specifically relating to each of the themes in the analysis. These are discussed in sequence below.

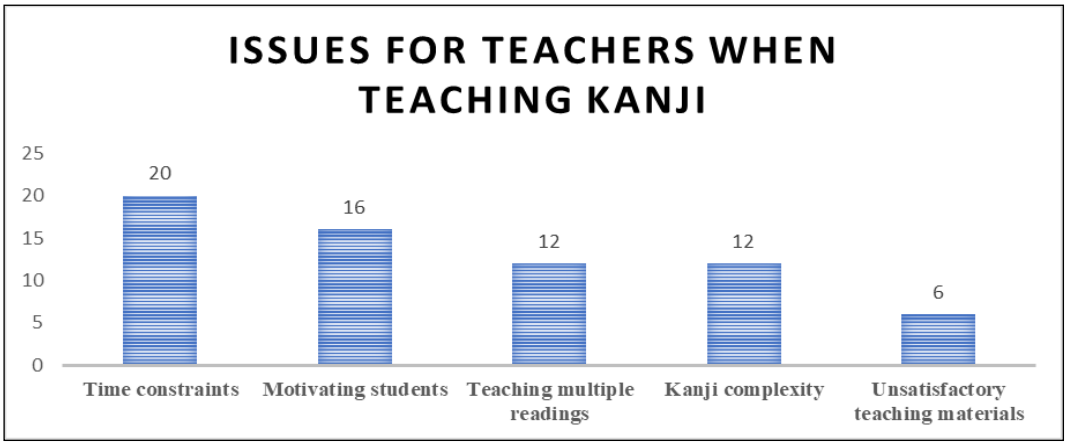



*Figure 7: Issues for teachers when teaching kanji*

#### 5.2.1.1 Time constraints

The most common complaint reported by teachers was that the time constraints under which they were working presented serious difficulties for effective kanji teaching. One illustrative example that was mentioned in the survey relates to the Leaving Certificate[17] cycle, which prescribes a 2-year period for teaching the entire Japanese syllabus. Within that time frame, teachers are required to provide students with instruction not only on the traditional language skills of speaking, listening, reading, and writing but also on cultural information. In addition, the guidelines that relate specifically to kanji are somewhat vague, with the syllabus providing a list of required kanji and the stated target being "using vocabulary and kanji correctly and appropriately" (Department of Education and Skills, 2004, p. 22). It is unclear from the text of the document which readings should be taught. Given the demands of a relatively short curriculum cycle and a relatively large workload, teachers appear to find it very difficult to make time for exclusive teaching of kanji characters in class. While the above example is from a 2nd level school, several of the respondents from 3rd level institutions highlighted the same issue.

[17] The Leaving Certificate is a state-sponsored examination in Ireland. Completion of the exam is required so that the Central Applications Office (CAO) can process applications for entry into higher education institutions (Central Applications Office, 2020).

Time constraints in class have serious implications for students. If teachers feel that they simply do not have time to teach kanji in class, they are likely to prescribe kanji learning in homework assignments instead. In effect, this is an outsourcing of kanji learning from the classroom to the self-study environment, where the teachers must rely on the learners' autonomy. While there is nothing unusual about teachers having to trust that students will put in the required work, the fact that teachers have to deprioritize kanji (rather than grammar, for example) seems significant. The specific demands of the curriculum are also likely to have an influence on such decisions. However, there is an important consideration to notice. If teachers are intuitively deprioritizing kanji learning in class and accepting that it is sufficient to treat it as a self-study endeavour, it is critical that learners are provided with appropriate methods of learning kanji. Based on the list of the teaching materials they used to teach kanji, the most likely scenario is that teachers are giving students homework exercises from the main module textbooks or from original materials they have made. In this process of outsourcing the kanji learning, the teaching materials are the key point of contact between teachers and learners. In light of this, it is essential to identify or design materials that are optimal for effective kanji learning.

#### 5.2.1.2 Motivating students

The next most common issue highlighted by teachers was how to motivate students. The responses indicate that teachers are very aware of student motivation in class, reporting that students can quickly become disinterested in kanji learning. According to the teachers, classroom kanji learning runs the risk of being a somewhat dull chore, lacking in fun and failing to capture the attention and enjoyment of students.

Although the subject of motivation is not a central part of this study, the findings of the survey show that teachers are aware of its implications and that it may have consequences for lesson planning and the use of supplementary homework materials. In teaching kanji, instructors seem to have a sense that there is a risk of losing the students' interest. Teachers mentioned their desire to inject fun into the learning process rather than relying on a repetitive system of exercises. Comments such as "how to make it fun", "it isn't as much fun as it should be", and "maintaining

the young learners' interest" show that there is an inherent conflict between responses on time constraints and motivation. Teachers seem to have a desire to instil an interest and appreciation of kanji in their students but are thwarted by the practical pressures of having to deliver specific curriculum targets. However, the problem is that when little or no time is assigned to kanji learning in class, it becomes increasingly difficult to achieve the goal of generating positive attitudes about kanji in the students. Teachers try to overcome this by supplementing the textbooks with original materials. For example, responses such as "written repetition and lots of games to create links between the characters" and "students find that it is easy to remember kanji if it is introduced in a story and pictures" show that teachers are flexible in their approach and try to circumvent the time constraint/motivation problem by using original teaching materials that engage the students. As with time constraints, it appears that the teaching materials are a crucial point of contact between teachers and students, affording teachers an opportunity to offset the perceived detrimental effects of outsourcing kanji learning from the classroom to the self-study environment. Responses indicate that the link between motivation and teaching materials must be considered carefully when designing materials for use in PHASE 2 by including tasks and exercises that are likely to engage students and hold their interest, even in the self-study environment.

#### 5.2.1.3 Teaching multiple readings

Another sub-theme highlighted by teachers was 'Teaching multiple readings'. The survey's respondents were employed in six different countries, and it appears that the respective systems have little in common in terms of guidelines on teaching kanji. In Ireland, for example, the official Japanese syllabus does not contain clear guidelines on how many readings or which readings are required to be taught. In contrast, the domestic Japanese system has a well-delineated curriculum and detailed guidelines but also allows for scope in the application of teaching and learning strategies, as seen in Section 5.4 below. In the absence of official directives, teachers must use their discretion and teach what they consider to be the most useful or most frequent readings. However, the survey indicates that teachers can sometimes struggle to help students understand and remember the multiplicity of readings for each kanji character. Respondents expressed some

frustration at not having sufficient guidance or teaching materials relating to the issue of teaching kanji readings.

The responses indicate that it is important to establish which kanji readings are prescribed in the module content and to make sure that sufficient exposure is given in the component analysis teaching materials. This could be done in a variety of ways, but one option is to ensure that all required readings are featured clearly in the practice materials and to include productive exercises that explicitly test all the readings. For example, phonetic cues could be used in productive exercises to reinforce the connections between characters. Character readings could be positioned conspicuously in rote writing exercises, or readings could be used in tandem with meanings when testing written accuracy.

#### 5.2.1.4 Kanji complexity

Another sub-theme that overlaps with the above is that of the general complexity of kanji. In Chapter 2, studies presented evidence that kanji complexity can place a high cognitive burden on the learner. Respondents to this survey report that kanji complexity impacts their teaching, highlighting the issue across several categories.

For this analysis, the envelope term ‘kanji complexity’ was used to include its compositional complexity (number of components, number of strokes) and other factors such as whether it was pictographic or ideographic since the use of mnemonics as an aid to learning kanji was mentioned in several responses. While mnemonics appear to be a popular choice in the LX teaching environment, it is not clear how effective they are. For example, an analysis by Richmond (2005) highlights some erroneous assumptions about the differences between L1 and LX learners. He finds that the textbooks contain the assumption that LX learners “should not use the methods employed by native learners” (2005, p. 20) and criticises the mnemonic techniques used in Henshall (1988) and Heisig (2007) as examples of kanji being needlessly decoupled from the vital phonological information contained within. Given the likely time constraints in LX classes and the lack of clarity

around the effectiveness of using mnemonics as a pedagogical response to kanji complexity, it may not be necessary to include them in component analysis materials in this study.

The responses also indicate that kanji complexity has a direct implication for teaching methods, especially when the class includes learners from diverse L1 orthographic backgrounds. The majority of teachers reported that they give explicit instructions on stroke order during class, supplementing the visual aids in the textbook. This is not particularly surprising where the LX learners are from an alphabetic background and are not familiar with writing systems with intricate stroke orders. However, where the learners are a mixture of $L1^{alpha}$ and $L1^{logo}$, it can impact teaching. For example, one respondent states that "I have western students, including British and Chinese students in class, which affects learning kanji/Japanese". This shows that the nature of students' L1 can have implications for teaching methods since kanji complexity is presumably less of an issue for $L1^{logo}$ learners. While in this survey, the majority of respondents indicated that their students were $L1^{alpha}$, the responses relating to kanji complexity underscore the need to take into consideration how to optimally design teaching materials for students who have incongruent L1 orthographic backgrounds. The issue of computer fonts was also mentioned and should be given brief consideration. Materials should use standardized fonts that are clearly legible, especially in examples that provide model characters written in cursive fonts.

#### 5.2.1.5 Teaching materials

Finally, some teachers highlighted the issue of unsatisfactory teaching materials. The evaluation of textbooks is discussed below as a separate theme since there was a diverse response in that category. However, for context, some of the critical responses include comments such as, "No professional materials that suit the learner", "Creating teaching materials and finding good reference books", "Too much vocabulary in the textbook", and "Not many examples given (in the textbook)".

This problem was not widespread in the responses and did not appear to be a serious issue relative to those discussed above. There were a larger number of responses that endorsed teaching materials on the whole. The purpose of highlighting the negative comments about teaching materials here is to understand the possible areas where improvements could be made and to consider how to incorporate those improvements into new materials. Where there were critical comments about teaching materials, responses mention problems with the type of examples used in the materials. "Not many examples" and "examples of kanji use that are too difficult" are typical of this. Another criticism was that kanji was treated as a separate entity to the rest of the learning, presented in appendices as lists to be learned. The following response typifies this criticism: "Kanji are treated separately as an appendix to each chapter. No extra aids for memory are given, and there is no discussion of radicals or how one kanji might relate to another". These responses suggest that using a contextual approach whereby kanji are integrated concurrently with the other learning outcomes should be considered in the new materials, as well as carefully calibrating the difficulty level of the exercises.

### 5.2.2 Perceived issues for students

Teachers also offered opinions on what they felt were the most pressing issues for students learning kanji, based on their observations from direct contact with the students in classrooms and on their evaluation of written work submitted by their students. Figure 8 below shows five key areas highlighted by teachers in their responses to survey questions, with the number of coded references relating to each theme.

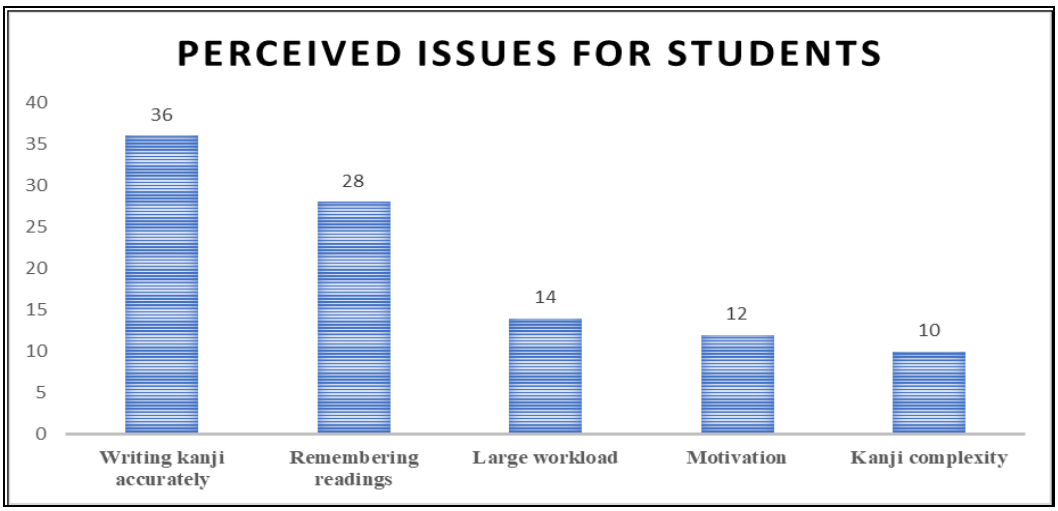



*Figure 8: Teachers' perceptions of issues for students learning kanji*

#### 5.2.2.1 Writing kanji accurately

The responses indicate that teachers strongly believe that their students struggle most with reproducing accurate written representations of kanji. This is based on their observations from students' written work, which contained errors relating to the number of strokes, stroke direction, accurately writing characters that could be correctly recognized when read, and difficulty writing visually complex characters. Given that the majority of the learners referenced in the survey were $L1^{alpha}$ learners, the teachers' perceptions appear to align with findings discussed in Chapter 2, which showed that alphabetic learners can struggle to form accurate representations of kanji in their memory, leading to written errors when trying to reproduce them. This indicates that when designing and implementing component analysis in this study, the materials should include a sufficient number of kanji exercises that test the productive skills of the learners, avoiding an over-reliance on developing receptive skills only. The inclusion of these exercise types in the component analysis materials may help the learners overcome what seems to be a particularly challenging aspect of kanji learning.

#### 5.2.2.2 Remembering multiple readings

Teachers also report that students had ongoing problems dealing with the multiplicity of readings in kanji characters. The combination of this with the above issue of writing kanji appears to have a compounding effect, with several respondents emphasizing both of these problems directly contributing to overall difficulties in helping students develop their kanji proficiency. Teachers

point not only to the multiplicity of readings but also to the differentiation between ON and KUN readings and the multiplicity of semantic information in tandem with readings. As with writing kanji accurately, the design of component analysis materials should, where possible, avail of opportunities to aid the learners in remembering the various readings of each character. It may be possible to include exercises that specifically target kanji readings and to relate them to other characters that share the same readings in an attempt to reinforce the connections between phonetic characters that share common components. The new materials should also consider how to increase awareness of phonetic components that can offer clues to full character pronunciation, thereby aiding the learner in recalling the pronunciation of known characters and possibly helping relate that knowledge when encountering unfamiliar characters.

#### 5.2.2.3 Motivation and workload

Motivation and workload are also highlighted as related issues that could potentially have an impact on student performance. According to teachers, these two issues can interact to produce unwanted outcomes. For example, teachers noted that the sheer number of kanji required to be memorised could place a burden on students, which in turn has a negative impact on their motivation. Several teachers remarked that memorisation is an indispensable aspect of learning kanji but that it appears to be something that students find challenging.

Judging by the responses, the consequences of overloading students with work could be quite damaging and could seriously impact their attitudes towards learning kanji. This is an important point to note when designing and implementing component analysis for PHASE 2. It means that the materials must be calibrated to produce the maximum effect, but without burdening the students such that they lose interest or enjoyment. Lesson plans must also take into consideration the balance of in-class work and homework so that the workload is properly distributed across both environments.

#### 5.2.2.4 Kanji complexity

Teachers report that students find kanji complexity to be an ongoing problem, noting that students have trouble with visual complexity, the compositional similarity between characters, elaborate stroke order rules, and trouble remembering which component is situated in which area of the character. As with writing kanji accurately, it seems clear from the responses that a key consideration in designing component analysis materials is to include exercises that serve to heighten awareness of compositional elements in the characters so that learners will develop the ability to distinguish visually similar characters and components. The materials, therefore, should include some way of explicitly comparing characters or components so that the differences become more apparent and more readily committed to memory.

When asked about whether they teach stroke order guidelines to students, 76% of teachers reported that they did. This question did not ask for further detail on how they taught stroke order or whether they explicitly tested the knowledge through the use of productive exercises. A minority of 19% of teachers reported that they did not teach stroke order whatsoever. While teachers seem to indicate that stroke order is an important aspect of teaching kanji to LX learners, this does not align with findings on how visual complexity affects the processing of L1 readers, as discussed in Section 2.4.5. Nonetheless, the question of how to integrate the teaching of stroke order must be considered in the lesson plans and materials. For example, it may be sufficient to use standard stroke order references, such as a textbook, rather than placing additional emphasis on this aspect of kanji learning in the new component analysis materials.

### 5.2.3 Evaluation of textbooks

The 42 respondents to the survey listed a total of 19 textbooks that they used to teach the prescribed curricula. The focus of the questions was on which textbooks were used to teach kanji and how the teacher evaluated it (See Appendix D for a detailed list of questions). In some cases, the use of a specific textbook was mandatory. In most cases, the choice of the textbook was discretionary. The

textbooks listed by teachers for inclusion in this analysis are a mixture of grammar primers, general workbooks, and kanji-specific workbooks. Respondents rated the textbooks on a 5-point Likert scale from 'Very Poor' to 'Very Good' according to how well they perceived the materials to perform in teaching kanji. Figure 9 below shows the distribution of textbook evaluations from JFL teachers and the numbers of coded references for each evaluation in the thematic analysis.

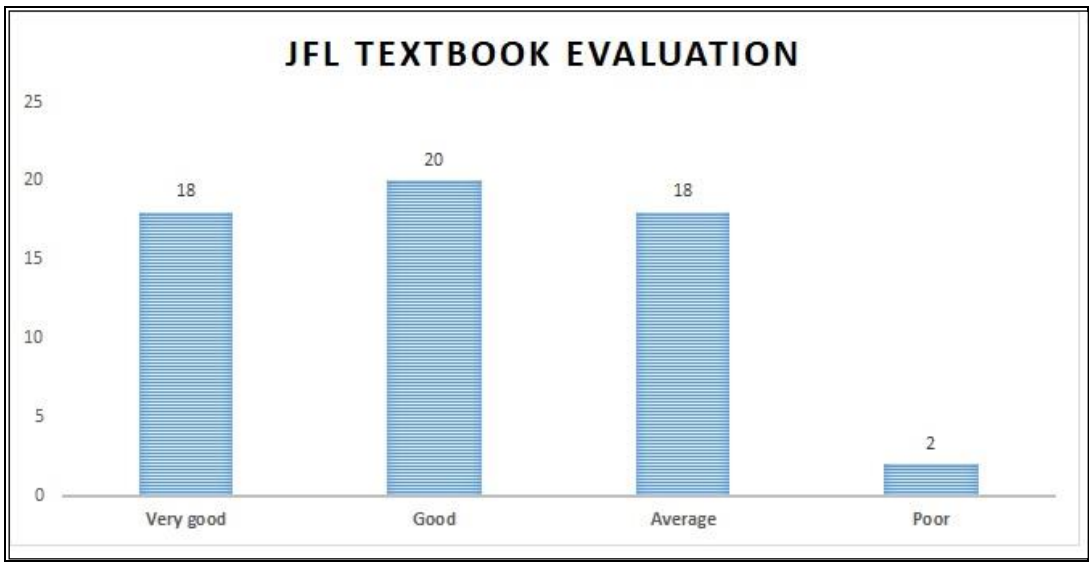



*Figure 9: Textbook evaluations by JFL teachers*

The majority of teachers rated the textbook they used as 'Good'. Textbooks rated 'Very Good' or 'Average' had equivalent numbers of coded references. Textbooks rated as 'Poor' accounted for only a small number of the overall total. No teacher rated the textbook as 'Very Poor', even though there were some cases in which the choice of the textbook was not made by the teacher. Teacher evaluations of textbooks are relevant because they reveal biases, areas of weakness, or highlight features that are likely to be very useful to learners. In addition, a teacher's perception of the strengths and weaknesses of a textbook may have direct consequences for students since the selection of a textbook is often the responsibility of the teacher. Table 3 below shows a sample of the explanatory comments from respondents who rated specific textbooks.

*Table 3: Teachers' evaluation of JFL textbooks*

| **Textbook** | **Rating** | **Quotation from respondent** |
|---|---|---|
| Nakama | Very Good | "The kanji introduced in each chapter is strongly connected to the topic of each chapter, and it makes me easy to teach". |
| Basic Kanji, Vol 1 | Very Good | "Concise but effective introduction, plenty of example sentences, good selection of kanji & kango, variety of exercises, overall, good to show the concept of kanji and how to best learn kanji". |
| Genki 1 | Good | "kanji are used regularly in the texts; the choices make sense to a non-native learner and correspond to students' needs". |
| Practical Kanji 500 | Good | "They have categorised kanji in topics". |
| Nihongo Kantan | Average | "Good meaning/pronunciation/stroke order/examples etc. but lacks visual aids". |
| Genki 1 | Average | "There are examples of kanji use that are too difficult for the students of that level". |
| Marugoto | Poor | "Not many examples". |

One aspect of textbooks that teachers reported being particularly beneficial was how strongly the examples were connected to the learning outcomes for a given lesson. In addition to the responses above, a further comment makes this more explicit: "Kanji vocabularies are appearing in the reading of the chapter, relevant to the topic". The same issue was highlighted when teachers listed unsatisfactory elements of the textbooks, with responses mentioning that sometimes kanji were treated separately, presented in different sections and in an unrelated way to the chapter's learning outcomes. This indicates that teachers strongly value kanji exercises that are firmly rooted in the context of other aspects of the learning process, such as the target grammar structures or reading comprehension exercises. The fact that teachers appear to value such an approach, where the target kanji are grounded contextually within the lesson outcomes, suggests that such an approach should be considered for inclusion in component analysis materials. One possible way to do this would be to ensure that full kanji words and kanji compounds contained in the module's prescribed vocabulary lists are used extensively in the component analysis exercises. This would serve to strengthen the link between the module content and the practice exercises by grounding the exercises in the context of the lesson.

In response to a question asking what kind of supplementary materials are used to teach kanji in conjunction with textbooks, a majority of responses indicated that teachers regularly create original materials or use readily available materials made by other teachers. Particularly in cases where the kanji exercises were deemed weak in the textbooks, teachers used a wide variety of supplementary materials and techniques to mitigate the perceived deficiencies. These included slides to explain kanji etymologies, course-specific kanji dictionaries, self-made kanji quizzes, "Lego-style linking of character parts on a board", self-made tests, printouts, card games, practice sheets, original games, and others. The use of digital applications was also mentioned. Responses included a variety of educational websites, standard social media websites, mobile device apps, desktop computer software, digital novels, and electronic dictionaries. The high degree of originality seen in these techniques suggests that teachers believe that kanji should be taught in a holistic way, integrating the exercises into the context of the current lessons, and practised in a way that is engaging to the student. The design of component analysis should include a variety of exercise types, including exercises that are likely to be engaging for learners. The possibility of integrating digital applications or online resources in the learning process should also be considered since responses suggest that their inclusion might be beneficial to learners.

### 5.2.4 Conclusions from survey of JFL teachers

The responses from the survey show that teaching kanji in academic institutions can present teachers with serious challenges. Teachers are often frustrated by time constraints in class that force them to make compromises. The majority of teachers seem to intuitively focus on kanji as an appropriate candidate for deprioritizing in the classroom, shifting the bulk of the learning to the self-study environment of the learner. If this is unavoidable in a practical situation, it is vital that component analysis teaching materials and lesson plans are designed with this in mind. In doing so, there is still a danger that it might become more difficult to motivate students by fostering positive attitudes towards kanji learning. This is exacerbated by the challenges that come with teaching the complexity of kanji to an L1$^{alpha}$ cohort. However, a key finding from this survey is that teachers appear to have a very strong belief in the role that teaching materials play in bridging the gap

between the classroom and the self-study environment and offsetting the undesirable consequences of the issues highlighted. The use of original teaching materials featured in many responses, showing that teachers place such high value on materials that they will spend time to create their own in areas they deem the textbook to be lacking. In light of the responses, it seems clear that designing and implementing component analysis materials must take into consideration how best to deal with these challenges.

In terms of how the above finding can be used in more concrete terms, one of the key areas should be a focus on writing. A common theme in the responses was how challenging it was for students to reproduce kanji in writing accurately. This finding is not particularly surprising since it is also a recurring feature in studies that examine the writing errors of LX learners of Japanese and how factors such as cross-linguistic influence could manifest as difficulties in reproducing accurately written kanji, as reviewed in Chapter 2 (see Hatta et al., 1998; 2002, and Chikamatsu, 2006). The survey findings support these observations further and show that, for students, there appears to be a barrier of sorts when it comes to either encoding the information in the first place or in its proper retrieval. A breakdown in either of these processes could result in such writing errors. Rose (2017) describes such memory encoding as "links we make between new information and known information in our long-term memory" and argues that "the success with which the information is stored is dependent on initial encoding and the strength of the memory trace to retrieve this information" (2017, p. 27). Depending on their level, learners may have little prior knowledge of kanji and, therefore, little consolidated information in the long-term memory onto which new information is mapped. As such, it is crucial that learners develop the skill of successful memory encoding as soon as possible in the learning process. The survey shows that teachers intuitively make various attempts to help students do this, such as the use of kanji maps, requiring students to use kanji in diaries, kanji quizzes, analysing social media posts containing kanji, fill-in-the-blanks kanji exercises, and many more. However, it is still unclear exactly how such activities differentiate between memory encoding and retrieval. The techniques used by teachers may produce positive results, but an explicit awareness of the underlying rationale for using these exercises would be

welcome support for teachers who struggle to design materials or teaching plans best suited for their students. In other words, it should be possible to design teaching materials in a more well-defined way, whereby specific exercises or activities address the initial memory encoding process, while other exercises and activities address the retrieval process. Exercises that involve rote writing have been used successfully in both L1 and LX materials, as discussed in Chapter 2. Such exercises could be included in the component analysis materials as a measure aimed to strengthen the memory encoding process. Exercises that target the retrieval process must also be included so that learners have sufficient practice in linking the kanji representations to other stored information.

Teachers also reported that students appear to have difficulty remembering the multiple readings associated with kanji characters. This also supports findings from previous studies that show that the processing of phonological information in kanji can be a problematic area for learners, irrespective of whether they are L1$^{alpha}$ or L1$^{logo}$. As discussed in Section 2.5, studies such as Toyoda (2000), Tanaka (2015), and Morita (2019) suggest that learners who are unfamiliar with morphophonemic[18] orthographies like Japanese may over-rely on a semantic-dominant mechanism of processing, leading to precisely the problem described above. While the findings from this survey tend to support this, the key question is how learners could be helped to overcome such challenges. As discussed in Chapter 2, the development of a fully functional system of dual-route processing of both semantic and phonological information appears to be an indispensable skill if they are to progress in kanji learning. Recommendations seen in Chapter 2 included explicitly teaching kanji compositional features (H. Yamashita & Maru, 2000), teaching semantic and phonological connections in tandem (Hagiwara, 2016), and teaching kanji as collections of components rather than collections of strokes (Chikamatsu, 2005). The design of component analysis materials should put these recommendations into practice. To do this, early in the module, it is necessary to include several lessons that focus specifically on explaining the compositional aspects of kanji, such as the relationship between semantic radicals and phonetic components.

[18] Japanese is considered morphophonemic because it combines native Japanese and Sino-Japanese morphemic and phonemic alterations (Vance, 1978, p. 8).

Furthermore, the materials should include practice exercises that use phonetic cues (KUN-yomi and ON-yomi) in tandem with character meanings and to associate those with character components. Crucially, the materials must have a focus on facilitating an awareness of individual components in characters through repetitive practice that involves productive exercises requiring the learner to generate components and relate them to components in other known characters.

## 5.3 Analysis of JFL textbooks

This section presents the findings and discussion of the analysis of JFL textbooks. As discussed in Chapter 4, all kanji explanatory references and productive exercises in the source materials were assigned the term ‘kanji iteration’ for this analysis. These kanji iterations were divided into a total of eighteen discrete categories. The categories were subsumed under the three general subdivisions of ‘Component’ (6 categories), ‘Single-Character’ (6 categories), and ‘Compound’ (6 categories). Instances of those eighteen categories were assigned a binary code of ‘1’ or ‘0’ according to whether they were present or absent in each textbook. This allowed for standard frequency statistics to be generated using IBM SPSS Statistics 24.

### 5.3.1 Kanji iterations (overall)

Table 4 shows the descriptive statistics from the SPSS analysis. It shows the percentages for each of the eighteen categories, indicating the percentage of textbooks which contained any instance of each specific category of kanji iteration.

*Table 4: % of textbooks containing categories of kanji iterations*

| Kanji Iteration Category | % | N |
|---|---|---|
| component meaning reference | 30% | 23 |
| component meaning exercise | 13% | 23 |
| component reading reference | 17% | 23 |
| component reading exercise | 9% | 23 |
| component writing reference | 30% | 23 |
| component writing exercise | 17% | 23 |
| single-character meaning reference | 87% | 23 |
| single-character meaning exercise | 57% | 23 |
| single-character reading reference | 87% | 23 |
| single-character reading exercise | 83% | 23 |
| single-character writing reference | 74% | 23 |
| single-character writing exercise | 70% | 23 |
| compound meaning reference | 91% | 23 |
| compound meaning exercise | 87% | 23 |
| compound reading reference | 91% | 23 |
| compound reading exercise | 87% | 23 |
| compound writing reference | 87% | 23 |
| compound writing exercise | 57% | 23 |

The table shows a disparity between Component iterations and Single-Character/Compound iterations. For example, the most frequent component iteration was ‘Component Meaning Reference’, which shows a value of 30%. This should be interpreted as demonstrating that of the 23 JFL textbooks in the analysis, approximately 30% contained at least one reference to the meaning of a component. Conversely, it means that approximately 70% did not contain any reference whatsoever to the meaning of an individual component. The least frequent Component iterations were ‘Component Reading Exercise’ (9%) and ‘Component Meaning Exercise’ (13%). This indicates that only a small minority of the textbooks tested a learner’s knowledge of component meanings or pronunciations. On the other hand, the table shows a minimum of 57% for all iterations in the Single-Character or Compound categories.

Table 5 below shows the same kanji iterations sorted from highest-to-lowest values by frequency. For clarity, ‘Compound’ is shown in orange, ‘Single-Character’ is shown in blue, and ‘Component’ is shown in green.

*Table 5: Kanji iterations sorted from highest to lowest frequency of presence*

| **Kanji Iteration Category** | **%** |
|---|---|
| Compound meaning reference | 91% |
| Compound reading reference | 91% |
| Single-Character meaning reference | 87% |
| Compound writing reference | 87% |
| Single-Character reading reference | 87% |
| Compound meaning exercise | 87% |
| Compound reading exercise | 87% |
| Single-Character reading exercise | 83% |
| Single-Character writing reference | 74% |
| Single-Character writing exercise | 70% |
| Single-Character meaning exercise | 57% |
| Compound writing exercise | 57% |
| Component meaning reference | 30% |
| Component writing reference | 30% |
| Component writing exercise | 17% |
| Component reading reference | 17% |
| Component meaning exercise | 13% |
| Component reading exercise | 9% |

The values from above can also be summarised by taking an average for each category, as shown below in Table 6.

*Table 6: Kanji iterations average by category*

| **Category Average Values** | | |
|---|---|---|
| Compound | Single-Character | Component |
| 83% | 76% | 20% |

While it is clear that the source materials show a preference for Single-Character and Compound iterations, it is not so clear why the number of Component iterations is so low. In a study

considering best teaching practices for languages like Japanese and Chinese, Everson (2011) recognises that textbooks can be weak in the area of component analysis, claiming that technology can "provide the capability to animate characters, rapidly deconstruct the characters into their component parts through animation and the use of color" (2011, p. 264). He recommends that "textbooks, then, should include more of this information so that students can begin to view characters as forms not composed of random strokes, but instead as a principled orthographic system" (2011, p. 264). The findings in this section indicate that his recommendation does not appear to have materialized in current JFL publications. Even the more recent publications, such as Marugoto (Kijima et al., 2013), contained no component kanji iterations whatsoever. It is difficult to see how such choices can be justified when considering the data available on kanji processing and the abundance of opportunities that customisable digital applications have brought in recent years. If such recent publications are to be considered as the latest evolution of kanji pedagogy, the decision to avoid component-based kanji iterations should be re-evaluated. This should be a consideration in the design of new materials since the findings above suggest that relying solely on current JFL textbooks will not provide the learner with enough exposure to component-level references and exercises while implementing the strategy.

### 5.3.2 Kanji iterations (sub-categories)

Table 5 and Table 6 above showed the frequency of each of the individual 18 types of kanji iterations under the broad categories of Component, Single-Character, and Compound. To further compare how JFL textbooks use references and exercises, the data was refined into more detailed categories. Each of the three broad categories above was divided into three subcategories of iterations of 'Meaning', 'Pronunciation', and 'Writing'. This produces a graph with nine categories (3 categories x 3 subcategories), each of these being represented by a bar in the graph in Figure 10 below.

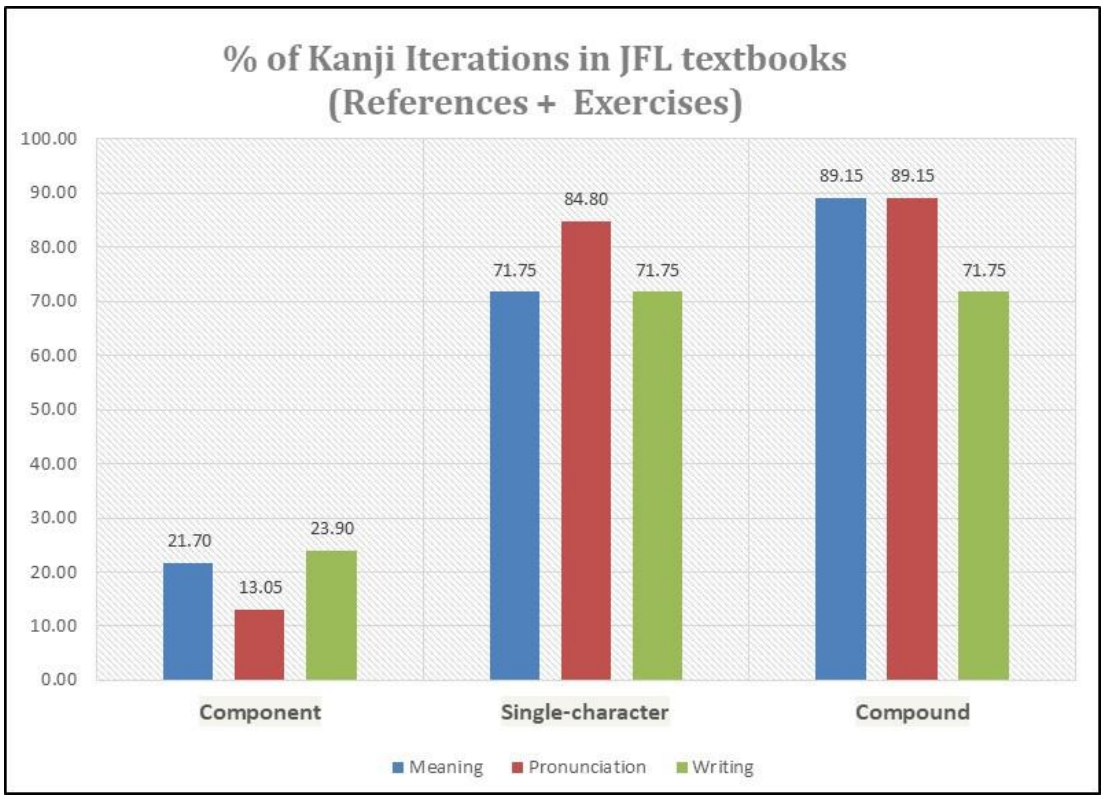



*Figure 10: % of kanji iterations in JFL textbooks (references and exercises)*

Interpreting the graph should be done with the understanding that references and exercises have been merged. For example, the first bar on the left of the graph (blue bar marked as 21.70) represents 'Component Meaning' kanji iterations. The findings show that 21.70 % of JFL textbooks contained either an explanatory reference to a component's meaning or a productive exercise that explicitly tested a component's meaning. As another example, the bar on the furthermost right (green bar labelled 71.75) represents 'Compound Writing' kanji iterations. This finding shows that 71.75% of JFL textbooks contained an explanatory reference to a compound's written representation or a productive exercise that explicitly tested how to write it.

The graph shows that for Component iterations, Meaning and Writing are slightly prioritized over Pronunciation. This is an indication that when Component iterations do occur in textbooks, they are often explanations of a radical's meaning or stroke order, or perhaps exercises that involve writing a specific component. For example, 'Genki' (Banno et al., 1999) features some exercises that provide a dominant radical and require the learner to write missing components. The lower number

of Component pronunciation iterations suggests that phonetic components are not featured strongly in the materials, even when components are explicitly referenced.

In contrast, the findings show that Pronunciation iterations in Single-Character (84.80) and Compound (89.15) were the most frequent on average, slightly above Meaning and Writing. These kinds of iterations are references or exercises that emphasise individual ON-yomi and KUN-yomi or the pronunciation of a full Japanese word. This is not particularly surprising since it is recognised that the presence of multiple readings is one of the most challenging aspects of learning kanji. Since learners have difficulty in assimilating multiple readings, there appears to be a good reason for such an intense focus on pronunciation and phonetics. In terms of how this relates to the design of component analysis teaching materials, it appears that JFL textbooks can be used as a reliable resource for practising pronunciation on the level of the character and compound, but that they should be supplemented in the area of component pronunciations. New materials should compensate in this area since it appears that component analysis is under-utilised in the current JFL textbooks, missing the opportunity to implement what seems to be a potentially effective kanji teaching method.

### 5.3.3 Kanji iterations (exercises only)

The next finding focuses only on the productive exercise iterations to gain a clearer picture of how often textbooks are explicitly using exercises to test the learners' knowledge on any given type of kanji iteration.

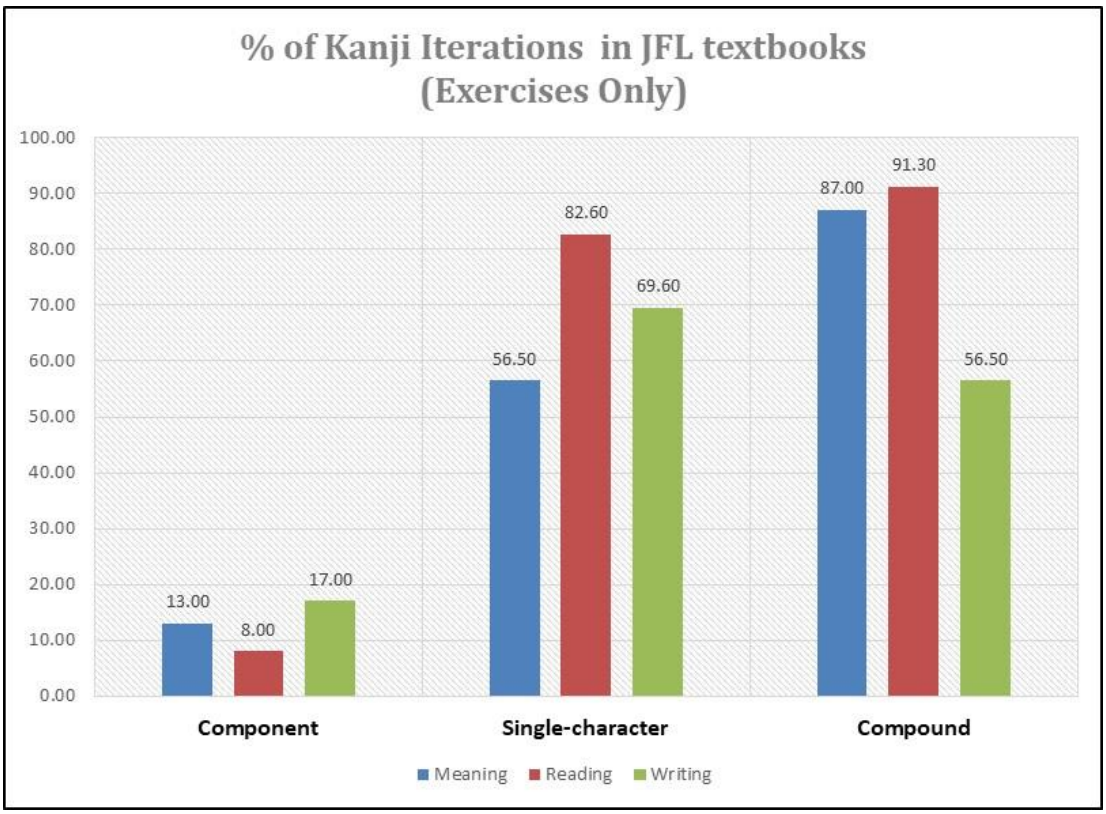



*Figure 11: % of kanji iterations in JFL textbooks (exercises)*

One notable finding shown in Figure 11 above is that only 8% of textbooks contained any exercise that tested the pronunciation of a component. This number is in stark contrast to the high numbers of exercises in the other categories. This is further evidence that textbooks seem to have a focus on the challenge of helping learners memorize the kanji readings and do so predominantly through exercises that test knowledge of single-character readings or compound word readings. However, given the fact that approximately 60% of the characters on the Joyo Kanji literacy list are categorised as containing a phonetic component (Katsuo Tamaoka et al., 2017, p. 699), it seems that exercises that test the pronunciation of phonetic components are somewhat under-represented in the JFL textbooks. Given the importance of learners developing the skill of extracting phonological information from components, the design of new materials should take this into account by including exercises that also test the learners' knowledge of pronunciation on the component level, where it is practical to do so.

Another notable finding is the large difference between Component Meaning exercises (13%), Character Meaning exercises (56%) and Compound Meaning exercises (87%). The types of

exercises involved are generally simple translation exercises, and it seems clear that the textbooks favour a contextual approach more than testing the individual meaning of a character or component. By testing kanji knowledge in this way, in the context of full words or sentences, the assumption is that it will provide the learner with more benefits than testing single-character meanings. This approach aligns with studies such as Mori's (2002) work, which suggests "the individual characters are often familiar but the meaning of an entire word is not necessarily a derivative of the combined meanings of component characters" (2002, p. 376). Thus, it seems that the JFL textbooks' combined use of single-character kanji meaning exercises together with compound meaning exercises should be considered a positive trend for learners. However, a possible drawback is that Component Meaning exercises are too heavily under-represented, despite strong support for the component analysis approach seen in the studies discussed in Chapter 2 (e.g. Kubota & Toyoda, 2001; Toyoda & Mcnamara, 2011), which highlighted the benefits of having a sound understanding of morphological components. While it may not be necessary to have Component Meaning exercises on a par with Single-Character or Compound Meaning exercises, it should be possible to integrate them to a greater degree, bolstering the learner's morphological understanding and providing more connections to other areas of kanji learning. Thus, while it is clear that JFL textbooks can be used as an effective resource to teach semantic knowledge on the level of the character and compound, new materials should include greater use of productive exercises that test semantic knowledge on the component level, if possible.

### 5.3.4 Other findings

In addition to the main analysis relating to kanji iterations, other aspects such as stroke order, mnemonics, and kanji font type were also documented. These categories were assigned the same binary numbers to understand how frequently they featured in the source materials. Although these do not feature in the main statistical analysis, they were considered and included based upon the findings seen in the survey of JFL teachers. Of the 23 JFL textbooks used as source materials, 70% contained an explanatory reference to the stroke order of a target kanji, while only 4% contained a productive exercise that explicitly tested that knowledge. For mnemonic use, 17% of the textbooks

contained mnemonics for each target kanji presented, while 83% did not. Finally, 43% of the textbooks used a variety of kanji fonts in the explanations or exercises contained within.

### 5.3.5 Conclusions from analysis of JFL textbooks

The analysis was done with the goal of understanding how component analysis features in the JFL textbooks and to take the findings into account in the design of new materials. Taken as a whole, the findings show that a component-level approach is generally under-implemented. A key finding is that textbooks favour the use of Single-Character and Compound iterations to provide a relatively intensive focus on practising pronunciation and meaning. While this is likely to be very useful to learners, there seems to be an under-utilization of the same types of iterations on the component level. Given the evidence that developing an explicit awareness of both semantic and phonetic components is critical, as was seen in Chapter 2, it can be said that the general avoidance of component analysis in JFL textbooks is unwarranted. In terms of how the findings can inform the design of component analysis teaching materials, it seems clear that the new materials should include productive exercises that test semantic and phonetic knowledge on the component level, especially in cases where the materials are to be used in conjunction with a typical JFL textbook during lessons. This point will be revisited in Section 6.3 in the PHASE 2 methodology.

## 5.4 Classroom observation in Japan

This section presents the findings and discussion of two classroom observation sessions conducted in Japan, in conjunction with a description of the teaching materials used by the teachers of those classes. As explained in previous chapters, the aim was to seek opportunities to adapt potentially useful L1 kanji teaching strategies and materials for the LX classroom and to observe current practices of kanji instruction for L1, allowing for useful comparisons to be made with LX methods. It was anticipated that this information would be useful in the design and implementation of component analysis materials to be used in PHASE 2 of the study.

### 5.4.1 General observations

In both classes, the duration of the kanji instruction portion of the lesson accounted for approximately 10-15 minutes of the 45-minute class period. Both teachers began by introducing the topic of kanji learning indirectly, without explicitly mentioning kanji. For example, the 4th-grade teacher opened the class by talking about her favourite types of food and drink and then asking the students what kinds of food they enjoyed most. Having established the idea of having a favourite among various items or activities, she then told a story about seeing an interesting kanji character that she found to be visually pleasing. The teacher followed this by asking if the students had a particular kanji character that they considered to be their favourite. Students volunteered which kanji they liked and provided reasons for why they liked it, with some citing an affinity for the meaning associated with the character and others describing how they enjoyed writing it or its visual impact. By introducing the topic in this way, the teacher was framing the concept of kanji learning in a way that was intended to present it as something that can be enjoyed on an intellectual level (liking a kanji's meaning for personal reasons) as well as an aesthetic level (enjoying the appearance or process of writing a kanji).

It was apparent that both teachers considered motivation to be an important factor in teaching kanji to the children. The attempts to ground the learning in a fun introduction were evidence of this. By engaging the students in this way, teachers began the process of instruction by framing it as something that had a direct relationship with the individual student. By asking students about their favourite items (such as food) and then transferring that concept to kanji, a personal connection was established between the learner and the target of the learning. Although this might seem trivial on some level as it could be seen as an artificial way to gain the students' attention, it may have direct transferability to the LX learner. There is a body of evidence that supports the hypothesis that motivation can play a significant role in kanji learning for the LX learner (e.g. Kondo-Brown, 2006; Nesbitt & Müller, 2016; Mitsuko Tanaka, 2013, 2014; Van Aacken, 1999). If the learner could find some kind of personal connection with kanji that helped them enjoy the learning process, especially in the early stages as they become familiar with kanji, it could conceivably help

form the basis for a successful attitude towards learning kanji. For example, the Van Aacken (2009) study mentioned above involved using a CALL program to help students with kanji learning. Digital applications seem to be an attractive option on the face of it, but this appears to be predicated on motivation. Van Aacken states that "findings indicate that instrumental motivation was a dominant factor; metacognitive strategies and a positive attitude toward the CALL program are also influential factors in mastering kanji" (1999, p. 113). It is clear from the classroom sessions that motivation is a crucial consideration in L1 kanji learning approaches.

After the introductions, both classes proceeded to the main learning outcome. For the 4th grade class, the aim of the lesson was for students to develop a sense of awareness of compositional features of the target kanji characters. The teacher introduced several kanji on the blackboard and described features such as the radical's name, the radical's meaning, the character's meaning, several typical readings, the stroke order, and several words that the teacher indicated the students might have seen in their day to day lives. This was followed by an exercise in which students were provided with stickers on which kanji components were printed. The task was to recreate several complete kanji characters by placing the stickers on a base of pre-printed partial kanji glyphs[19]. In one example, the base paper contained the component 宀 (upper position radical meaning 'roof'), and the students were required to recreate the full kanji 案 by sticking the components 女 and 木 in the correct positions underneath the 宀 component. Figure 12 below is a recreation of the exercise.

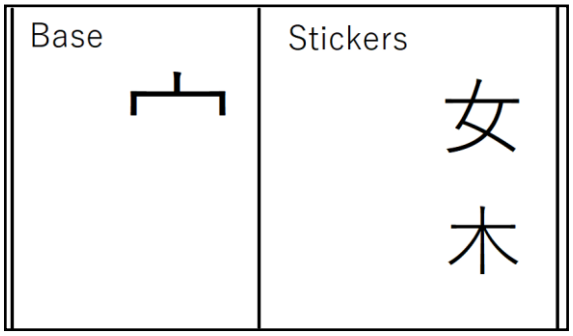



*Figure 12: Recreation of kanji composition exercise*

[19] "A character or an abstract symbol that represents some concept or object. The graphical representation of a character is called its glyph. In digital typography, each glyph is usually represented as a 2–dimensional bitmap" (Lai, Yeung, & Pong, 1997, p. 308).

The teacher emphasised that a key aspect of the exercise was to get the balance correct, asking that students first check their work and then bring their completed kanji to the teacher for feedback. In some cases, the teacher then directed students on how they might improve their completed version. The base was plastic-coated so that the stickers could be removed and repositioned as many times as students wanted. In presenting the task as a kind of game, the teacher once again framed a technical task (accurately reproducing the compositional balance of kanji components) in a way that students appeared to enjoy. The students seemed to use a process of trial and error to complete the exercise by sticking the lower components onto the base and then checking their version against the version on the board. This was repeated for several different characters. The materials were well suited to this task, as students repositioned the components many times as they attempted to match the model character perfectly. Students appeared to find the activity engaging and interesting.

For the 6th grade class, the teacher used a more explicit approach to teaching target kanji characters. As with above, new characters were introduced on the blackboard, and the key aspects of the character were pointed out. In this case, the teacher also included information about stroke types. Stroke type in Japanese is a complicated system that contains a taxonomy of at least 26 stroke types and several further subdivisions (Apel & Quint, 2004; Yencken & Baldwin, 2008). Rather than using this, the teacher used a simplified categorisation that focused on whether the stroke was a 'stop-type' ('tomeru'), a 'jump-type' ('haneru'), or a 'sweep-type' ('harau'). Figure 13 below shows examples of these, with (a) showing stop-type, (b) showing jump-type, and (c) showing sweep-type.

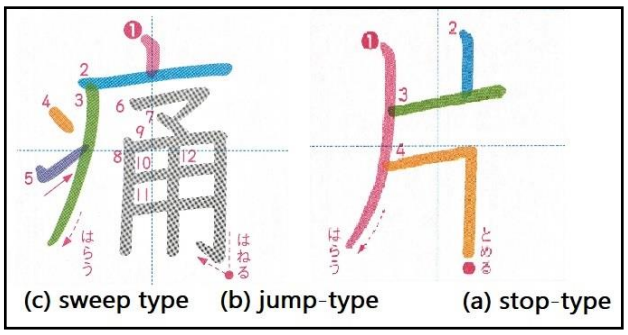



*Figure 13: Examples of stroke types*

Students were then provided with printed exercise sheets that contained all the information described by the teacher, as well as several exercises that required them to reproduce the kanji character and several of its dominant readings. It was clear that the 6th-grade teacher was using a strategy that focused more on the technical task of recreating the kanji correctly. The kanji learning portion of the class was mainly used to practise writing the target kanji, with the teacher reiterating the parameters above as students practised and providing real-time feedback during the session.

The focus on components and composition in the above exercises was an attempt to enlist visual memory to aid the kanji learning task. By separating the components and then requiring them to be positioned in the correct alignment and spatial balance, the act of recognizing individual components is practised. The use of this type of exercise is supported by experimental data on L1 Japanese children. For example, Koyama (2008) examined the role of visual skills in L1*morph* children learning kanji by using a battery of auditory, phonological, and orthographic tasks. One of the orthographic tasks was to ascertain whether a presented kanji was real or not, with pseudo kanji containing incorrect permutations of radicals or other components. The findings showed that "kanji literacy performance was strongly predicted by visual memory (particularly visual long-term memory)" (Koyama et al., 2008, p. 41). The task in that study was very similar to the exercise observed in the classroom. Since there is evidence that LX learners have difficulty extracting both semantic and phonological information from kanji efficiently, exercises such as the above could be used to good effect in LX teaching materials.

Another point to note in the classroom observation was the level of detail the teachers used when explaining the stroke order of each target kanji character to heighten compositional awareness in the students further. Although stroke order is a complex topic, a simplified version that still highlighted specific details like stroke 'stops', 'jumps', or 'sweeps' was used. This can be considered another difference between L1 and LX, in that while stroke order is certainly a feature of LX instruction, it is not generally taught in such detail. For example, while the survey of JFL

teachers indicated that 76% of teachers do teach stroke order in some way, it was not apparent whether this was productively tested. The open-ended questions indicated that while teaching stroke order was common, it was not a priority for teachers. For example, one respondent advocated for rote learning but noted that "they hope for the best, rather than focusing on the detail of each stroke". The analysis of JFL textbooks also included a finding that showed that while 70% of the source materials contained an explanatory reference to stroke order, only 5% tested that knowledge. On the other hand, studies like Tamaoka and Yamada (2000), discussed in Section 2.4, suggest that stroke order may not play a significant role in overall kanji knowledge, at least for L1 readers. Thus, while there appears to be an interesting difference in L1 and LX teaching approaches to stroke order, it does not constitute clear enough evidence that the design of component analysis materials should include an explicit focus on this area of kanji.

Finally, the inclusion of a self-evaluation element and real-time feedback from teachers could be a useful reference in the design of new materials. The time given to kanji in the L1 classroom allowed for greater input from the teachers, with feedback and evaluation being provided during class. In addition, some of the exercises contained an element of self-evaluation as students corrected the positioning of kanji components before receiving feedback from the teacher. While there are still relatively few studies that investigate self-evaluation specifically in relation to LX kanji learning, there is a broader body of literature that explores the value of learner autonomy and self-regulation. As discussed in Chapter 2, the use of language learning journals may be an avenue that is worthy of further exploration. While time constraints might limit the amount of in-class kanji instruction possible for LX learners, the inclusion of some type of self-evaluation or feedback system should be considered for inclusion in component analysis materials.

### 5.4.2 Samples of teaching materials

The following images are samples of the teaching materials that were provided by elementary school teachers during the meetings before or after the classroom observation sessions. Some salient features of the samples are presented below, with labels added for clarity.

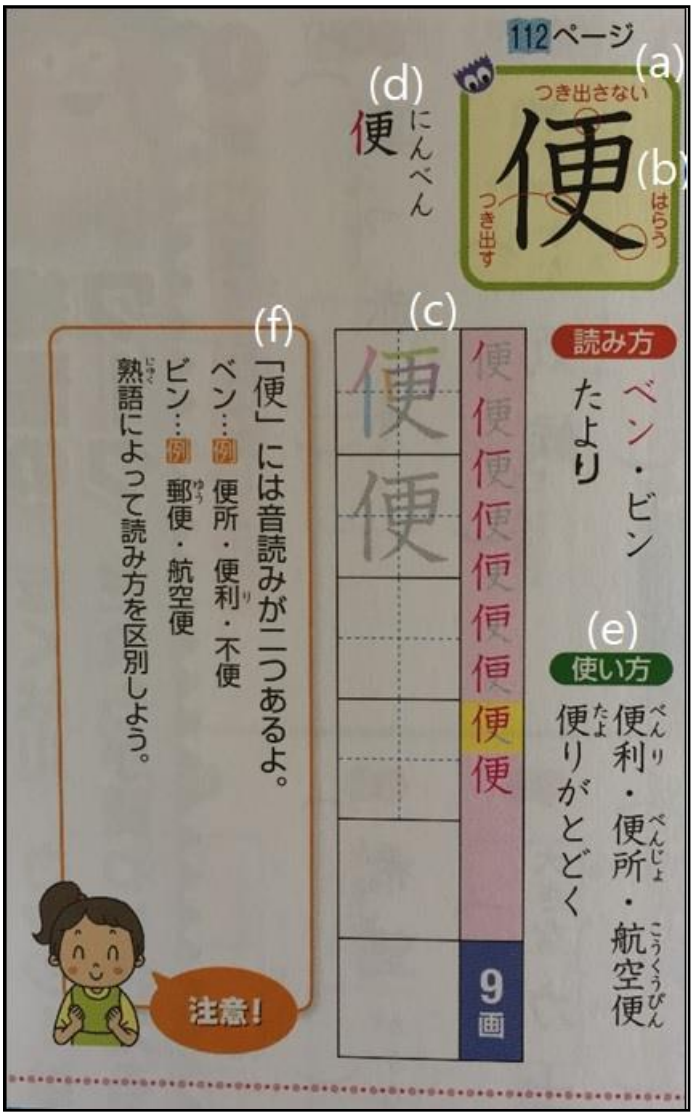



*Figure 14: Labelled sample of 4th-grade teaching materials (Hatake, 2014)*

The 4th-grade sample above contains features that were discussed by the teacher during the course of explaining the activity. For example, there is a focus on reproducing compositional accuracy, with (a) simple instructions on stroke length, (b) stroke type, (c) stroke guide and number, as well as (d) an explicit explanation of the name of the dominant radical component in a colour-coded example. Typical vocabulary items that feature this kanji are also listed (e). There is a supplementary explanation given, which points out some key features of the character (f). In this case, the kanji has two very common ON-yomi readings, which is somewhat unusual since the

majority of characters have only one dominant ON-yomi reading. The explanation provides common examples for each of these two readings and advises the learner to use the appropriate reading for any given word.

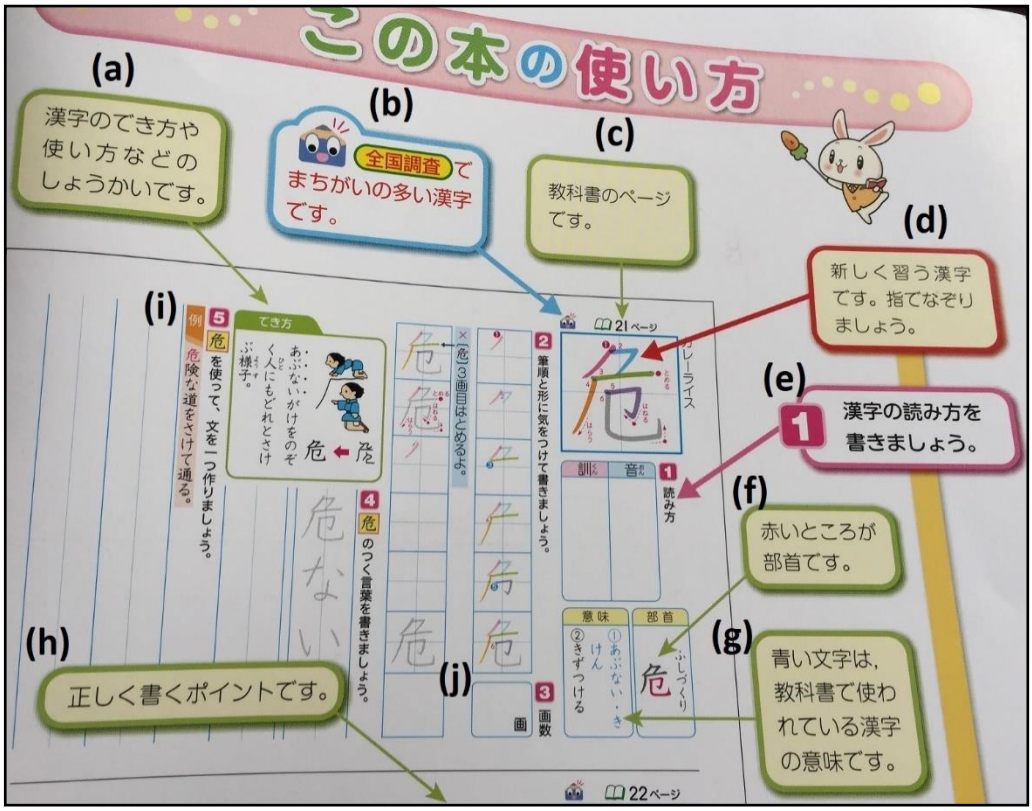



*Figure 15: Labelled sample of 6th-grade teaching materials (Mizutani, 2013)*

The sample above is from a 6th-grade workbook that was used in the second observed lesson. This page is the explanation of how to use the workbook and is presented at the beginning of the book. The figure has been labelled from (a) to (j) in order to identify the features contained within. Table 7 below lists the features in the figure.

*Table 7: Features of 6th-grade teaching material sample*

| Label | Explanation of feature |
|---|---|
| (a) | A simple introduction that includes etymology and graphical information to aid memory. |
| (b) | An icon cautioning that this particular character is commonly mistaken, according to a national survey. |
| (c) | A page reference. |
| (d) | The target kanji character to be practised. Learners are advised to trace the character with their finger. |
| (e) | An exercise requiring the learner to write the target character's readings. |
| (f) | Colour coding that identifies the dominant radical component of the target character. |
| (g) | A simple explanation of the meaning of the target character. |
| (h) | Guidance on how to reproduce accurate written representations of the target character. |
| (i) | Sample sentences and exercises requiring the learner to produce sentences using the target character. |
| (j) | Writing exercise that includes further guidance on accurate reproduction. |

As with the 4th-grade materials, there is a focus on reproducing compositional accuracy in writing the target kanji. Within (j) above, the exercise features colour-coded strokes, a numbered stroke order system, a simplified explanation of stroke type, arrows to indicate stroke angle and direction, with visual and written guides for stroke length, such as a dot to indicate the point to finish the stroke. There is also general advice on how a character might be best reproduced in writing ('pay attention to the stroke order and the shape while writing').

The images from the textbooks above highlight some general differences between L1 and LX kanji materials. One obvious difference is that the L1 materials have a stronger focus on instilling a sense of compositional awareness and accuracy in the learner, as evident from the abundance of information relating to strokes, positioning, and components. The fundamental information, such as common ON and KUN readings, meaning, and representative vocabulary, is prominent. For example, the materials consistently present the target kanji with its dominant radical named and highlighted in colour. Furthermore, the stroke order and stroke number information are

supplemented with detailed instructions on the length and angles of the strokes, also providing the names of the types of strokes used. Colour is also used for individual strokes in the non-radical components of the character. Simple explanatory guidelines are used in order to point out the correct way to write the character, as well as cautionary notes where it is deemed that an error is likely to be made. Etymological information is included sometimes, particularly in the materials aimed at later elementary grades such as 6th-grade. In contrast, the focus in the JFL textbooks (even in those that focus exclusively on kanji) appears to be more concentrated on references and exercises that attempt to help learners with the challenge of memorizing multiple kanji readings, with single-character-level and compound-level iterations being preferred, as seen in Section 5.3. While this difference could simply be a reflection of the challenges that the different learner groups face, the design of component analysis for LX learners could incorporate some of the features seen above in an attempt to facilitate awareness of components.

Another detail that highlights a difference between L1 and LX materials is the inclusion of the simple guidelines for writing kanji, seen in the L1 materials. While it can be argued that these guidelines are specifically aimed at children, these could have value for the LX learner too. In the 6th-grade teaching material sample, one of the guidelines urges the learner to trace the kanji character with their finger. As seen in Chapter 2, studies by Itaguchi (2017) and Thomas (2015) provide evidence that the use of air-writing can benefit all learners, whether they are L1 or LX. The inclusion of finger-tracing (a variation of air-writing) in the L1 teaching materials is justified by findings such as the above. However, in this study, it featured only in the L1 teaching materials and not in the LX materials. Differences such as these suggest that LX learners may not be availing of potentially beneficial strategies that have direct empirical support from literature and experimental data.

### 5.4.3 Field notes

Notes taken during the lessons and the informal interviews with the teachers are briefly summarised in the table below.

*Table 8: Summary of field notes from classroom observation sessions*

| **Summary of field notes** |
|---|
| Small (10-15 minutes) but regular amount of class time allocated for kanji learning and practice |
| Standardised curriculum, with large scope for how the curriculum is taught |
| Explicit focus on teaching awareness of character composition in early grades of elementary school |
| Systematic practice requiring learners to reproduce accurate written representations of target kanji |
| Extensive use of productive exercises testing meaning, readings and compositional accuracy |
| Increased use of exercises that emphasise lexical knowledge across kanji in 5$^{th}$ and 6th grades (e.g. distinguishing between characters and words whose meaning is similar) |
| Complementary use of component-based, single-character-based, compound-based exercises |
| Use of materials containing elements of self-evaluation |
| Decreased emphasis on explicit compositional practice from junior high school onwards |

The summary of the field notes above further highlights some differences between the L1 and LX approach to teaching and learning kanji. During the informal interviews with L1 teachers, it emerged that kanji teaching sometimes may only comprise as little as five minutes in a class period, but that it is given consistently so as to provide regular practice and maximize exposure, thereby reinforcing learning. The time is also used for kanji writing practice so that teachers can give feedback in real time, pointing out areas where mistakes are common or providing precise instructions on specific details such as composition. As discussed above, this is markedly different from the experiences of JFL teachers who struggle to balance the demands of the curriculum with perceived best practices. Of course, it must be remembered that L1 teachers have many more contact hours with learners than JFL teachers. Nonetheless, even with the considerable time

constraints evident in LX teaching environments, there may be value in trying to include short but regular moments of kanji instruction where possible.

JFL curricula will naturally vary with each institution's particular goals, or whether it is an official state examination, for example. While this is unavoidable as a reality of modern 2nd and 3rd level education, it must be noted that there are probably distinct advantages in the L1 learning environment as a result of having a standardised curriculum. In addition, Japanese is a core subject in elementary school, unlike JFL contexts, providing obvious advantages. With domestic Japanese publishers having to conform to specific learning outcomes based on this standard comes an abundance of teaching materials from which to choose. The L1 teachers indicated that a wide variety of workbooks, drills, quizzes, games, etc., exist solely for the purpose of advancing kanji proficiency. The market for these is stable precisely because the curriculum is essentially the same all over the country. For LX learners and JFL teachers, the textbooks and materials vary widely in their approach and might be difficult to match with a curriculum, as evidenced by JFL teachers reporting extensively that they prefer to include supplementary materials. Care should be taken in designing new materials so that the prescribed textbook can be supplemented in areas that do not fully align with module learning outcomes.

As with the samples of materials, the field notes show that the amount of emphasis given to developing awareness of compositional features such as strokes and components differs, with L1 instructors and materials showing a stronger preference than LX for including explicit references and exercises that train the learner in this area. This is more evident in the earlier L1 grades, such as 1st-grade to 4th-grade. As learners progress to 5th and 6th grades and beyond into secondary education, the focus is shifted away from composition and more toward lexical or morphological features of kanji. There does not appear to be an analogous trend in JFL teaching methodologies, and it is difficult to argue for its inclusion, given the fact that LX learners must first contend with establishing a base of vocabulary and grammar. Nonetheless, the question of to what extent the

compositional features should be emphasised appears to be a notable point and must be considered in the design of new materials.

### 5.4.4 Conclusions from classroom observations

When considered in the context of the findings from the survey of JFL teachers and the JFL textbook analysis, the classroom observation sessions provided useful insights into differences between L1 and LX kanji teaching materials and methods. One notable difference is the high degree to which compositional accuracy is emphasized in the L1 materials. This was reflected in the approach to teaching seen in the lessons, as well as from general information in the field notes. Furthermore, it appears that for L1, several of the types of strategies and techniques observed in the lessons have direct support from literature and empirical data. For LX, there are recommendations and data available, but they do not seem to be present in the materials to the same degree. If LX kanji learning is to progress, it must surely begin to incorporate the recommendations from experimental studies that are revealing new possibilities. In particular, if JFL teachers continue to rely heavily on teaching materials, it is essential that those materials are of the highest quality and reflect the growing body of literature and experimental data that suggest that learners might benefit from explicit training in compositional awareness and accuracy.

In terms of adapting L1 materials in the design of component analysis materials, there appears to be some scope for including more techniques that facilitate compositional awareness in more detail. For example, materials could include exercises that test the spatial balance of components or strokes. The use of air-writing or colour coding for different aspects of the characters might also be a consideration in aiming to develop compositional accuracy. The inclusion of self-evaluation elements could also have value for learners. There may be scope for including fun exercises that engage the learner and generate positive motivation towards the process of learning kanji. These considerations are discussed in Chapter 6, which details the design of the component analysis teaching materials that are to be used in PHASE 2 of the study.

## 5.5 Implications for PHASE 2

Before moving to PHASE 2, it is necessary to review the overall findings of PHASE 1 briefly and to consider how the three stages discussed in this chapter can inform the design and implementation of component analysis materials. Findings from the survey of JFL teachers were particularly useful as they provided insights into practical challenges facing teachers in real classroom situations. The findings suggest that time constraints will likely result in having little time for kanji practice in class, meaning that the design of materials must ensure that they are also suitable for use in the self-study environment. To equip students with the skills to use the materials on their own, lesson plans early in the semester should include explicit instruction about kanji compositional features like radicals and phonetic components. Since motivation is also important, it is essential to try to include a balance of engaging exercises and to provide sufficient practice while not overburdening the students with an excessive workload. There were many useful suggestions about types of activities and exercises in the survey responses that are worthy of consideration.

The Analysis of JFL Textbooks was useful because it showed the large (and unwarranted) imbalance between component-level kanji iterations relative to single-character or compound-level iterations, highlighting the need for new materials to have a stronger focus on components. The analysis also revealed that productive exercises that test the learners' knowledge of components are particularly under-represented, indicating that the new materials should include a combination of productive exercises and explanatory references where possible, especially in lessons where the materials are to be used in conjunction with a standard JFL textbook.

The classroom observation sessions in Japan offered insights into how L1 materials can be adapted for LX materials. For example, the strong focus on compositional awareness and accuracy seen in the L1 materials could be recreated in LX component analysis materials by including exercises that specifically test compositional balance or incorporate game-like activities in technical tasks. It may also be possible to include a self-evaluation element, which is an attractive possibility given that it

is likely that students will have to practise kanji on their own. The observation sessions also provided useful context on how L1 and LX kanji teaching methods can differ. While it is not advisable to draw direct comparisons, using short but regular amounts of class time for consistent kanji practice, as was seen in the L1 classes, could be a consideration.

The design of component analysis teaching materials proceeded based on the above findings. The final format of the exercises represents an attempt to synthesize the many recommendations from studies (discussed in Chapter 2) with the findings from PHASE 1 above, while seeking to ground the materials in realistic and pragmatic parameters. The materials were designed in a way that allowed them to be integrated into the module, conforming to the description and learning outcomes as closely as possible. As such, students were tasked with learning approximately 10-15 new kanji characters each week over the course of the 12-week semester. Based on the analysis carried out in PHASE 1, an initial design plan listed the main features that were considered important and practical to include in the exercises. Table 9 below shows the considerations that shaped the design of the exercises, with a brief explanation of the rationale for including them. Three exercises form the core of the component analysis materials. The table also shows in which exercises each feature was included, marked by (a) self-assessed kanji writing exercises, (b) kanji decomposition exercises, and (c) kanji glyph exercises. These exercises are described in detail in Chapter 6.

*Table 9: Design of ICA Exercises*

| # | FEATURES IN THE EXERCISES | RATIONALE FOR INCLUDING IN THE EXERCISES | EXERCISE |
|---|---|---|---|
| **1** | Should use both references and productive exercises | Standard textbooks show low use of productive kanji exercises that target components. A focus on reproducing written kanji could have potential benefits. | (a), (c) |
| **2** | Should use a mixture of component-based, single-character-based, compound word-based exercises, including rote-writing. | To avoid the type of imbalance revealed in the analysis of JFL textbooks and classroom observation in Japan and provide sufficient practice. | (b) |
| **3** | Should target the reader's eye within components | A prerequisite for component analysis is the ability to distinguish individual components effectively. | (a), (b), (c) |
| **4** | Should be practical for the learner to complete | Exercises should be easy to understand without requiring overly complex steps to complete tasks since learners may often have to do the exercises without the teacher's direct assistance. | (a), (b), (c) |
| **5** | Should be of an acceptable difficulty level | The exercises are assessed as an official part of students' module scores and must be fair. Motivation may also be impacted by overly difficult exercises. | (a), (b), (c) |
| **6** | Should include explicit decomposition of components | To facilitate the efficient extraction of both semantic and phonological information from the character. | (b), (c) |
| **7** | Should engage the interest of the learner | Perceiving kanji as a chore can impact student motivation. Game-like or puzzle-like activities were used to good effect by both L1 and LX teachers. | (b), (c) |
| **8** | Should be an appropriate workload on students | An excessive workload would likely impact student motivation and could affect performance. | (a), (b), (c) |
| **9** | Should include clear information about kanji readings. | The survey findings suggest that this is a problematic area for students. | (a), (c) |
| **10** | Must be able to be assessed as part of a university module | The exercises must provide students with a fair and accurate evaluation of their performance. | (a), (b), (c) |
| **11** | Must be fully integrated with module specifications and learning outcomes | The study was conducted on participants undertaking an officially assessed module at a university. | (a), (b), (c) |
| **12** | Should include self-evaluation, if practical | To develop learner autonomy and generate interest in the learning process. This is important since learners will often be studying kanji at home. | (a) |

While there were other considerations for inclusion from the PHASE 1 findings, such as the use of colour-coding, air writing, stroke order exercises, etc., the above table represents a practical attempt to synthesize the recommendations into a structured and pragmatic series of exercises. In terms of implementation, it was decided that lessons in the first four weeks of the semester would contain

short but regular periods of kanji instruction, featuring explicit explanations of kanji composition. The materials were introduced early in the learning process, allowing for real-time feedback to be given in class or in subsequent classes. Students were shown how to use digital applications that could help them complete the materials when they were studying at home. This approach prepared the students by establishing a base of kanji knowledge early in the module and by equipping them with the necessary tools to use the component analysis materials successfully.

# 6 PHASE 2: Methodology

## 6.1 Introduction

This chapter presents the methodology for the second phase of the study. The overall purpose of PHASE 2 is to answer the primary Research Question RQ1 (*To what extent does using a component analysis kanji learning strategy facilitate learners' awareness of the compositional features of kanji characters?*) and the sub-questions RQ1b (*What are the factors that influence the changes observed in kanji learners?*) and RQ1c (*What issues are highlighted by kanji learners who use 'component analysis' materials?*). Section 6.2 provides details on the participants in the three stages of data collection of PHASE 2. Section 6.3 explains the design and features of the component analysis teaching materials, called 'Intra-Character Awareness Exercises' (ICA), the design of which was informed by PHASE 1. Sections 6.4 and 6.5 provide an exposition of how eye-tracking data and kanji writing error analysis data were used to monitor changes in kanji processing by the participants over a 12-week period. Section 6.6 describes how a post-semester survey was used to gather student feedback on the exercises used during the module, with the aim of understanding some practical implications relating to the application of component analysis in teaching materials.

## 6.2 Participants

All three stages of data collection in PHASE 2 involved participants from the same cohorts. The participants were two groups of 1st year Dublin City University students. Both groups were taking the same Japanese language module. 'Group 0' (totalling 17 students) were ab-initio learners with minimal or no experience of kanji learning. 'Group 1' (totalling 9 students) were lower intermediate learners who had completed at least one year of kanji learning prior to taking the module. Although Group 1 participants had experience of learning kanji, they reported that they had never explicitly used component analysis during their studies. For each stage of data collection,

a subset of the total number of participants volunteered, resulting in variations in sample size for each data set. The teaching materials were integrated into the module's existing learning outcomes and were taught over the course of a 12-week semester.

## 6.3 Teaching materials

This section contains a detailed description of the teaching materials used in PHASE 2 of the study. The teaching materials, which are called Intra-Character Awareness Exercises (ICA Exercises), are comprised of three types of kanji exercises, the design of which was discussed in Section 5.5 above. The three exercises are (a) self-assessed writing practice, (b) kanji decomposition exercises, and (c) kanji glyph exercises. ICA Exercises are defined as a category of instructional exercises that targets the reader's attention on individual components or groups of components within kanji characters. The term 'intra-character' was chosen to intend the meaning of 'seeing inside the character'. The term seeks to emphasize the process of perceiving kanji as a group of discrete segments or components rather than as one whole entity to be processed. The term 'awareness' is used to refer to a processing mechanism in which efficient recognition and parsing of individual components are possible. Thus, the exercises aim to bring about in the reader an increased capacity for perceiving kanji characters not merely as an assemblage of individual strokes, but as a coherent grouping of recognisable components, with predictable relationships to each other and other characters, as per the goal of a component analysis learning strategy. This is done by using tasks that require a deliberate effort to scrutinize individual kanji components repeatedly and by relating the information in the components to previously learned kanji. In addition, characters and components are presented in tandem with semantic and phonological information so as to reinforce the connections between meaning and pronunciation at the level of the component, single-character, and compound. The aim of using these exercises is to enact component analysis in a practical and controlled fashion, taking into consideration a range of relevant factors revealed in the findings from PHASE 1.

### 6.3.1 Exercises

#### 6.3.1.1 (a) Self-assessed writing practice exercises

The first of the three exercises in ICA is a self-assessed writing practice exercise. This is an adaptation of a standard type of rote-writing exercise that is used in many workbook-style kanji publications. An exercise of this type typically involves the presentation of a single kanji character together with its most frequent readings (KUN-yomi and ON-yomi), a dominant English keyword to represent its meaning, a guide on how to write the character with a reference character in a cursive font, and other useful information such as high-frequency compound words that contain the target character. Figure 16 shows a typical example of this, from 'Basic Kanji, Volume 1' (Kano et al., 1989).

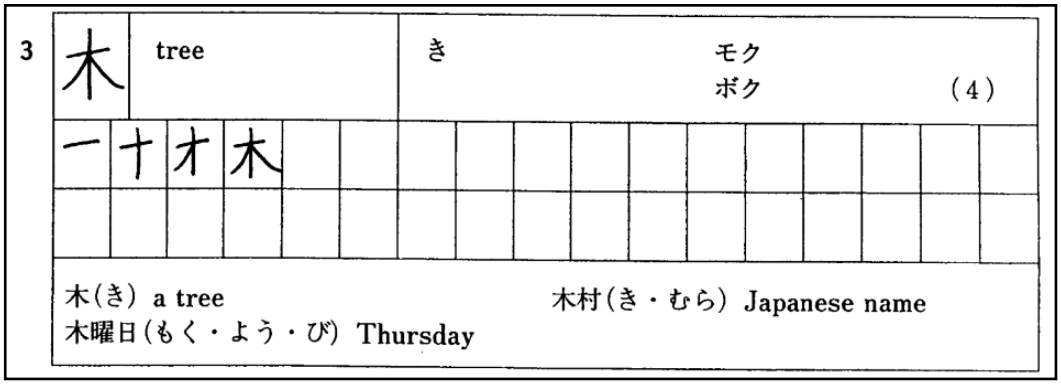



*Figure 16: Typical written kanji exercise*

A variation of this type of exercise was included to address specific features mentioned in Table 9, i.e. the inclusion of both references and productive exercises, the targeting of components, and clear information about kanji readings specific to the module. The adapted version of this type of exercise is also based on a self-assessed exercise that was observed in a classroom in Japan, discussed in Chapter 5 (Figure 12). During that lesson, 4$^{th}$-grade students were asked to position component stickers onto a base sheet containing radicals. Some of the useful elements of the exercise, such as explicit awareness of component positioning, self-evaluation, engagement, etc., are adopted from this for ICA Exercises by including writing practice of individual kanji characters (as per Figure 16 above) as well as a self-evaluation for each character (#12 in Table 9).

In the ICA Exercises version, guidelines on how to evaluate the written character were provided in the explanation of the materials. Students were asked to study the provided model character and then compare it with their own written attempts, paying attention to the individual components themselves. Instructions emphasized that students should scrutinize the character's composition itself (the actual components), the visual form (stroke length, angle, shape, etc.), and compositional balance (where each component is situated relative to the others). Based on those criteria, a self-generated grade from 1 to 10 was to be written in the top-right corner of the writing practice box, with '1' being a very inaccurate representation of the character and '10' being a perfectly written character. As indicated in Table 9, the point of the exercise is to draw the gaze of the learner 'inside' the character by requiring them to repeatedly scan its constituent components and become more aware of its compositional details. Figure 17 below shows a sample of what was shown to students during the initial explanation of how to complete the exercise.

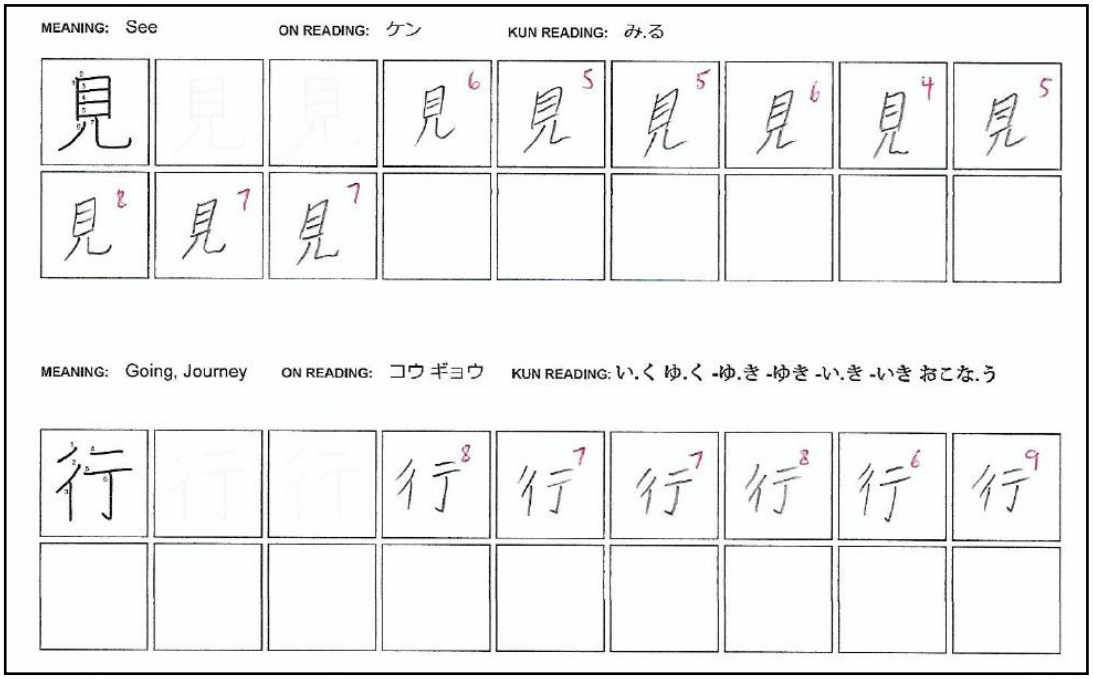



*Figure 17: Sample of self-evaluated written exercises*

The red numbers in the top-right corner represent the self-evaluated grade assigned to each written attempt, based on the perception of how well the attempt conforms to the model, according to the criteria outlined above. The dominant readings for each character are positioned in a conspicuous area of the page across the top of the practice boxes, rather than in one grouping in the top left, as is seen in many textbooks. The objective of this deliberate positioning was to make it easier to notice

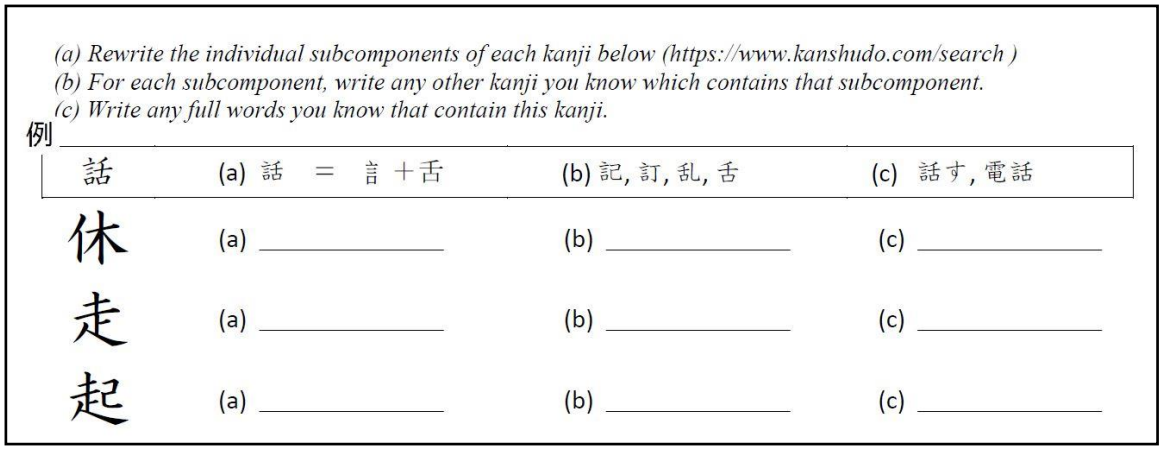
the readings of a character as the student's gaze repeatedly scanned back and forth between the model character and their own reproduction during the self-evaluation process.

The worksheets for each kanji lesson were generated using a free online tool called 'Kanji Worksheets'[20]. The kanji worksheets were made by using a customizable selection process to choose the characters for each lesson of the module. The resulting PDF was then edited to situate the character readings into the aforementioned modified positions on the page. These exercises were assessed by documenting how many characters had been fully completed with self-rated scores assigned to each character. See Appendix G for a sample of the self-assessed writing practice worksheets.

#### 6.3.1.2 (b) Kanji decomposition exercises

As discussed in Chapter 2, LX learners could benefit from developing a rounded knowledge of radicals and the capacity to process the semantic and phonological information in kanji effectively. Recommendations included using explicit character decomposition as a way to develop that skill. Given the apparent importance of such an approach, including decomposition in the exercises was deemed to be optimal. As outlined in Table 9 (Features #2, #3 and #9), the aim of these kanji decomposition exercises is to explicitly practise the process of deliberating separating out the individual segments of kanji characters. By requiring the learner to analyse each kanji character in terms of its constituent components, it increases familiarity with each of them. Additional tasks require the components to be related to other characters and words that were previously learned. Figure 18 below shows an excerpt from an ICA Exercises worksheet that uses these exercises.

[20] The tool is a digital repository hosted by GitHub (https://github.com/), a website that allows designers of digital software to manage the workflow of a coding project.



*(a) Rewrite the individual subcomponents of each kanji below (https://www.kanshudo.com/search )*
*(b) For each subcomponent, write any other kanji you know which contains that subcomponent.*
*(c) Write any full words you know that contain this kanji.*

例

| | | | |
|---|---|---|---|
| 話 | (a) 話 ＝ 言＋舌 | (b) 記, 訂, 乱, 舌 | (c) 話す, 電話 |
| 休 | (a) _____ | (b) _____ | (c) _____ |
| 走 | (a) _____ | (b) _____ | (c) _____ |
| 起 | (a) _____ | (b) _____ | (c) _____ |

*Figure 18: Sample of kanji decomposition exercise*

Students are presented with individual characters on the curriculum and are given three tasks to complete. Task (a) is to rewrite the character's individual components separately, decomposing the character into its constituent parts. This is presented in a pseudo-mathematical format such as '話＝言 + 舌' to make the exercise clearer. Task (b) follows the initial decomposition with an exercise requiring students to relate individual components to other full characters that they know. In the example above, a student could relate the radical 言 with other kanji in which it appears, such as 訂.

One purpose of this exercise is to reinforce the memory encoding of this particular component as well as linking it to the body of knowledge of characters that are already stored in memory. The desired outcome is that individual components will be recognized and processed more efficiently, with an awareness that each component recurs in other characters, perhaps contributing meaning or pronunciation to that character. Task (c) expands on this by requiring the student to write full words that contain the target kanji. In the example above, if the target character is 話, the task is to think of a list of full words that contain the character, such as 話す ('to speak') or 電話 ('telephone'). The aim of this task is to introduce a further contextual element to the learning, attempting to link not only the components but also the whole character to other items of vocabulary that are known or have been previously learned. It is hoped that this might mitigate one of the disadvantages that LX learners have relative to $L1^{morph}$ readers, which is that $L1^{morph}$ kanji learners already have an established foundation of lexical items onto which new kanji can be mapped, whereas LX learners do not.

Since this task involves several complicated steps, detailed instructions and examples were given to the students. Before the introduction of ICA Exercises, several classes were dedicated to introducing and explaining kanji, with lectures on radicals, components, stroke order, kanji categories, etc. Instructional websites such as Kanshudo (2020) and other digital resources were demonstrated, with a focus on showing students how to use a variety of online resources first to find kanji characters and then to access more detailed information about them. This was done to provide the students with a base of knowledge on kanji so that when they were tasked with decomposing a kanji, they would already understand that many characters are composed of several components, usually with one dominant radical. Figure 19 below shows an example from the kanji learning website Kanshudo (https://www.kanshudo.com), showing how to select a dominant radical from a character. The website then shows a breakdown of the character's radical and components (Figure 20), as well as other information such as meaning and readings. Other websites used were Kanji Jiten (https://kanji.jitenon.jp) and Kanji Chishiki (https://kanjitisiki.com/zyouyou/). Students were encouraged to use any digital resource that they found useful for viewing information about a character's radical and components.

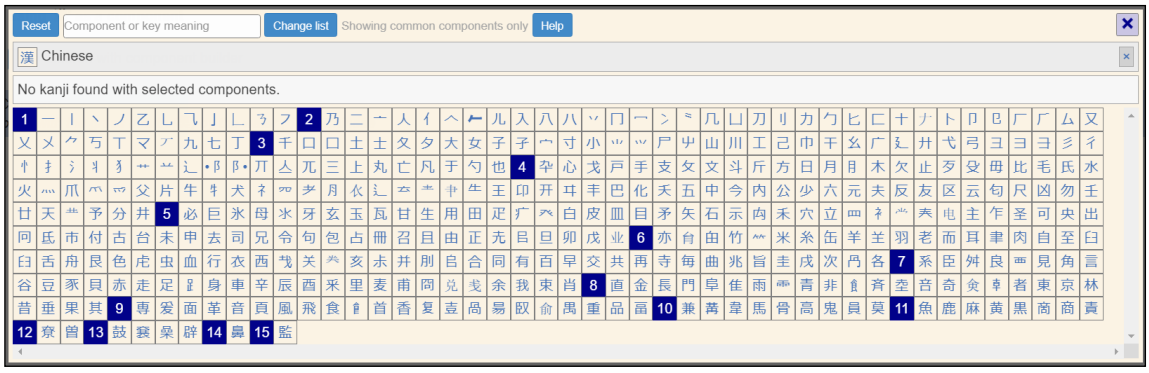



*Figure 19: Searching for radicals using 'Kanshudo'*

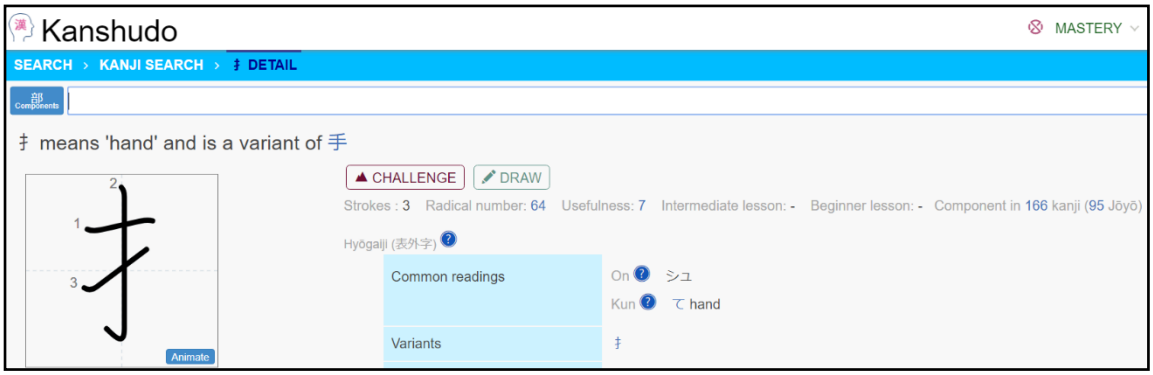



*Figure 20: Information displayed about a component on 'Kanshudo'*

These exercises were assessed by determining how successfully students were able to represent a given character in terms of its components, how well they were able to link that component to other characters on the curriculum that they had previously learned, and by how well they could relate the whole target character to other items of vocabulary that they were deemed to have learned previously. See Appendix H for more samples of the kanji decomposition exercises worksheet.

#### 6.3.1.3 (c) Kanji glyph exercises

The final exercise in the Intra-Character Awareness Exercises materials makes use of modified kanji glyphs. As per Table 9, the exercises address Features #1, #3, #6, and #9. For the purpose of these exercises, the glyphs are essentially visual representations of kanji that have had some alterations made to them. This exercise is an adaptation of the exercise discussed in Section 5.4, in which Japanese children were asked to reconstruct partial kanji. The puzzle-like format of that exercise seemed to generate interest and enjoyment for the children. Teachers attested that it was a popular activity and an effective one for familiarising the children with the concept of component recognition and compositional balance. To simulate the puzzle-like aspect of this exercise, glyphs were chosen as an appropriate choice. For example, using glyphs could allow a target kanji to be displayed with a missing component or some missing strokes. This provided the opportunity to target specific components in the learning process, such as commonly recurring radicals. Any combination of strokes or components could be manipulated or removed, allowing for the creation of highly customisable exercises and worksheets. Another benefit of using this approach is that each character can be presented as a variety of different glyph iterations. This allows the user to design a range of difficulty levels for the same target material. For example, a low difficulty exercise might present a target kanji as a glyph with one or two missing strokes, such that it already

has a strong resemblance to the complete version of the target kanji, making it easier to recognise. Increasing the difficulty for the same character might involve removing an entire component or more. The manifold possibilities of manipulating the characters provide the language instructor with a way of controlling the learning process in terms of target content, difficulty, and material design. The glyphs were generated using an online flash tool called ‘Glyph Editor’ (http://en.glyphwiki.org/glyphEditor.cgi), shown below in Figure 21.

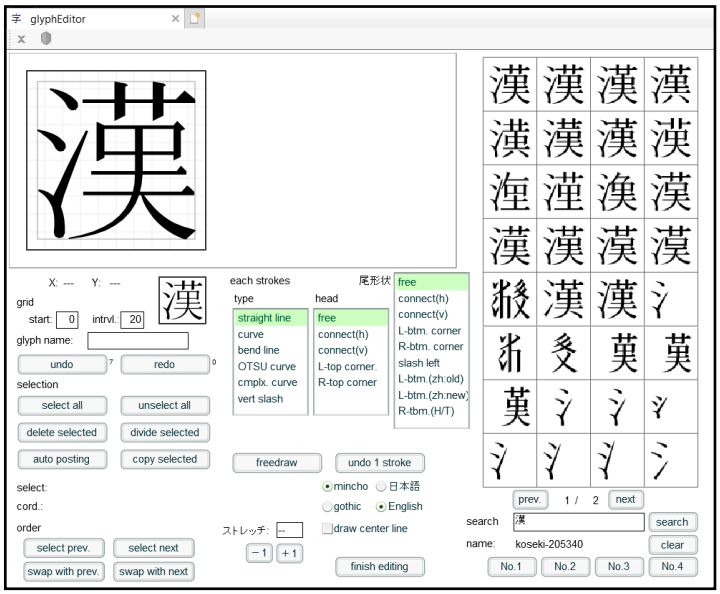



*Figure 21: Flash tool 'Glyph Editor'*

This tool allows the user to search for a kanji character and then manually alter its composition to produce a glyph that is a variation of the character. For example, the user can remove any stroke or combination of strokes and then generate a new image for use in a digital format. Figure 22 below shows the stages of the process whereby a component has been removed from a kanji character, producing a glyph that shows an incomplete representation of the target kanji. The process is to first search for a target kanji character. This is then selected (highlighted in red in Figure 22) and manipulated using on-screen tools with a variety of functions such as removal, addition, dividing, etc. When the target kanji has been altered to produce the desired glyph, this can be exported in a format that allows for further editing and use in standard word processing programs.

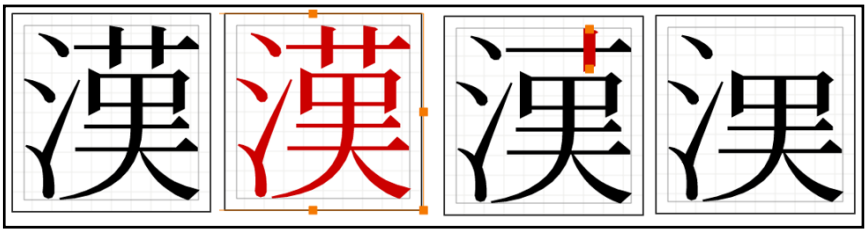


*Figure 22: Process of manipulating characters to produce kanji glyphs*

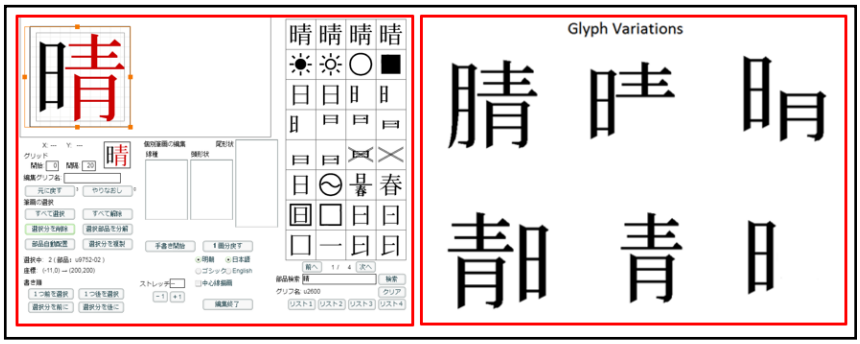



*Figure 23: Sample variations produced using 'Glyph Editor'*

Figure 23 above shows how the tool could be used to generate a range of variations on any given character. For Intra-Character Awareness Exercises, each target kanji was altered to produce a glyph in which a component or stroke(s) were missing. The final images were then inserted into an original template that was designed to deliver the weekly exercises. The template showed the glyph paired with the target character's meaning and dominant KUN-yomi and ON-yomi readings. The task first required students to analyse the glyph and then use the information presented in order to determine what the intended target kanji might be and how to generate a correct and complete representation of the character. An excerpt from a sample worksheet is shown below in Figure 24.

| | | | | |
|---|---|---|---|---|
| 夫 | はる | シュン | spring | |
| 百 | なつ | カ | summer | |
| 禾 | あき | シュウ | autumn | |

*Figure 24: Sample worksheet from kanji glyph exercises*

The exercises required the student to attempt to write the correct target kanji. The next step was to check whether the attempt was correct or not by referring to the textbook. The correct version would then be rewritten several times. These exercises were assessed on a weekly basis by documenting how many were fully completed and by judging how well students attempted to use the information to generate correct written representations of the target kanji. Appendix I shows a complete page of one of the worksheets that use this type of exercise.

## 6.4 Eye-tracking

To answer RQ1 (*To what extent does using a component analysis kanji learning strategy facilitate learners' awareness of the compositional features of kanji characters?*), eye-tracking technology was used before and after the semester (in conjunction with kanji writing error analysis) in order to accurately quantify the changes that happened between the two different time points. This was a crucial aspect in establishing the differences between groups over the entire course of the study. The eye-tracking data can also be represented visually for qualitative analysis. As discussed in Chapter 9, a small sample size is acknowledged to be a limitation of this study, and the findings must take this into consideration on that basis.

### 6.4.1 Participants

As described in Section 6.2, participants were 1st Year DCU students taking a Japanese language module. There were two groups, ab-initio learners (Group 0) and lower-intermediate learners (Group 1). A total of 11 students volunteered for participation in the eye-tracking portion of the study, with 7 from Group 0 and 4 from Group 1 completing pre-semester and post-semester sessions. Calculations of mean fixation times on Areas of Interest used data from all 11 participants. For the visualization of data, such as Heat Map and Gaze Plot data, four participants were used from each group.

### 6.4.2 Stimulus materials

Eye-tracking data was collected pre-semester and post-semester from both groups. A controlled list of kanji characters was used as stimulus materials for the eye-tracking data collection. There were several stages involved in the selection and control of these characters, informed by the review contained in Section 2.4. Kanji were first chosen from the module curriculum and then subjected to several stages of controls. A total of 180 kanji characters was available from the curriculum. Controls were implemented by using statistical data available on 'Kanji Database' (K. Tamaoka et al., 2017). The characters were first controlled for frequency by selecting only characters with concordant frequency values, as assigned by the above database. The next stage applied a control for visual complexity as it was anticipated that including characters with a large number of written strokes could result in erroneous conclusions. Only characters of medium visual complexity (6-12 strokes) were used. The remaining characters were next controlled for 'symmetry'. Symmetry in kanji is an indicator of how likely the left and right sides of a character will recur in other kanji compounds. Therefore, it is conceivable that characters with unbalanced symmetry could produce different responses than symmetrical characters from the participants. For example, "when a kanji occurs in fewer than five compounds, it occurs too infrequently to be symmetrical" (Tamaoka, 2017). It was anticipated that using a mixture of symmetrical and unsymmetrical kanji could result in processing differences. Therefore, only characters that were statistically symmetrical were used. Finally, the remaining characters were partially controlled for kanji category. Since the purpose of

using eye-tracking is to track changes in the processing of components, it was decided that characters that had a comparable number of components would be most suitable for use in the data collection. Characters classed as pictographs or as simple ideograms were not used as they were unsuitable for measuring saccades between components. Only characters classed as compound ideographs and phonetic characters were used because they generally contain at least two components within each character, allowing for measurements on how the reader's gaze moves between them. The final list of stimulus materials was 25 kanji characters that were of comparable frequency, visual complexity, symmetry, and category. See Appendix F for a full list of the characters used.

### 6.4.3 Method

For these experiments, a Tobii X60 XL with a 24-inch wide-screen monitor was used. It used a 60Hz sampling frequency. During data collection, the kanji characters were presented in 1600 x 900 resolution. The experiments were recorded, and data was analysed using Tobii Studio 3.4.5 1309, Professional Edition. As per the recommendations listed in the manufacturer's manual, the threshold distance from the participant's eyes to the terminal screen was set as 67 cm. A gaze sample of 80% was considered as an acceptable minimum threshold, based on Tobii guidelines that indicate that involuntary movements like blinking or looking off-screen usually reduce the gaze sample from 100% (Tobii Pro, 2016, p. 62). Gaze sample is a reflection of how much time the participant's eyes are on the screen, meaning that low sample rates can be excluded in the analysis. The mean gaze sample for all participants across the experiments was 94%, well above the minimum threshold.

Participants sat in front of the eye-tracking terminal and were asked to view the kanji characters silently as they were displayed. They were asked to simply allow their gaze to follow what it wanted without feeling the need to intentionally focus on any specific area or mentally generate meanings or pronunciations. Individual kanji characters from the source list were displayed in

sequence, with each character being shown for 4 seconds. The individual kanji were displayed in 400-point Meiryo font, large enough that a single character took up approximately 75% of the screen. The character size, font, and duration were selected after a process of trial and error during informal sessions, with volunteers recommending those settings as producing the least fatigue. Figure 25 below shows the scale of how the characters would have appeared while displayed to the participants on a full-screen monitor during the experimental setup.

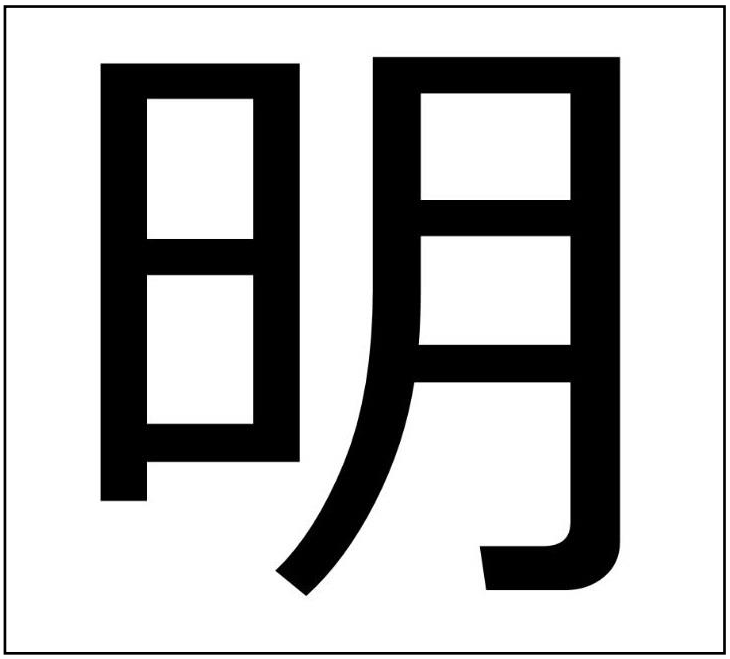


*Figure 25: Example of kanji stimulus materials*

### 6.4.4 Eye-tracking data analysis

Data was collected from each participant twice, once before the beginning of the semester and once again immediately after the semester. Three types of metrics were used in the analysis: (a) fixation times on Areas of Interest (AOIs) and categories of AOIs, (b) Gaze Plot output images, and (c) Heat Map output images. To analyse the fixation times, four sets of Paired Sample t-tests were performed for both groups. The data was first checked for distribution normality by using IBM SPSS Statistics 24 to generate descriptive statistics for each of the eight variables used in the eye-tracking fixation time data. See Appendix N for a detailed breakdown of the results, showing the mean, standard deviation, skewness, and kurtosis values for each of the variables. For all variables, both the skewness and kurtosis values fall within a range of -2 to +2, which is considered to be an

acceptable threshold in establishing whether a data set can be justifiably used in a multivariate analysis (Curran, West, & Finch, 1996; George & Mallery, 2010). The results of the normality tests indicate that the data is normally distributed and is, therefore, suitable for use in t-tests. The results of the Paired Sample t-tests are presented in Section 7.2.1.

One further point to note related to the t-tests above is that this study did not use statistical correction techniques such as Bonferroni correction. While such techniques can be an important addition to certain types of studies, decisions on whether to apply them or not appear to be predicated on the specific details of the test variables and how they are used in a study. For example, Armstrong (2014) points out three specific conditions under which correction is preferable. They are if "(1) a single test of the 'universal null hypothesis' that all tests are not significant is required, (2) it is imperative to avoid a type I error, and (3) a large number of tests are carried out without preplanned hypotheses (2014, p.502). These conditions do not strictly apply to this study since the eye-tracking fixation time data is one aspect of a broader analysis that seeks to integrate different kinds of observations into an overall conclusion. Likewise, Streiner (2017) outlines six conditions that could produce unwanted multiplicity in t-tests and which might warrant Bonferroni correction. These are testing in randomized controlled trials, testing for group differences across a number of outcome measures, using certain statistical tests like multiple regression, 'peeking' at data, using interim analyses, and using so-called 'fishing expeditions' in the data (2017, p.722). Again, these conditions are not strictly relevant to this study for the reason stated above. Furthermore, Rothman (1990) objects to the overuse of correction since "a policy of not making adjustments for multiple comparisons is preferable because it will lead to fewer errors of interpretation when the data under evaluation are not random numbers but actual observations on nature (1990, p.43). In light of the above, Bonferroni correction was deemed to be less applicable in this study and was omitted. Future use of eye-tracking data in kanji research, particularly studies involving larger sample sizes, studies that use larger numbers of statistical tests, or studies that rely primarily on eye-tracking data in their conclusions, should consider the use of statistical correction techniques.

In order to measure the cognitive load spent on a specific area of a kanji character, Areas of Interest (AOIs) were manually defined for each kanji. For each kanji character in the source materials, a minimum of two static AOIs was created. The 25 kanji characters were divided into 51 discrete components or areas, each of which was rendered into a distinct static AOI. The 51 AOIs were then divided into seven categories, using a standard Japanese radical taxonomy. These seven categories of AOI and corresponding icons are '*hen*' (◧ left components), '*tsukuri*' (◨ right components), '*kanmuri*' (⬒ upper components), '*ashi*' (⬓ lower components), '*tare*' (◸ upper left semi enclosure), '*nyo*' (◺ lower left semi enclosure), and '*kamae*' (◘ enclosure). See Figure 26 below for an example of AOIs used in the analysis.

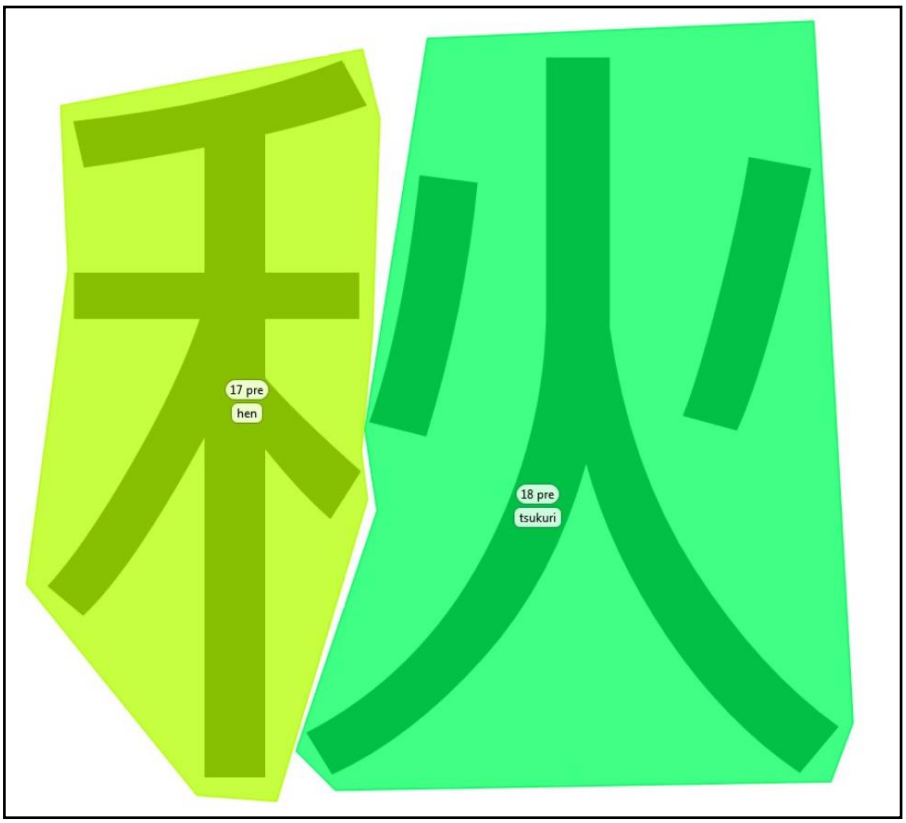



*Figure 26: 'hen' (left) and 'tsukuri' (right) AOIs for the kanji 秋*

These AOIs were analysed by measuring the mean and sum values of fixations on each of them. By categorizing the AOIs into the seven groups described above, it is possible to identify overall trends in how the fixations changed (by category) from the beginning of the semester to the end. In this study, the analysis involved a comparison of mean times spent on AOI categories pre-semester and post-semester for both groups. It also included a comparison between sum times spent on AOI categories pre-semester and post-semester for both groups.

The visualization of data, ‘Gaze Plot’ and ‘Heat Map’, was used for qualitative observation. Gaze Plot data is a dynamic visual representation consisting of dots overlaid on a source image, whereby “the size of the dots indicates the fixation duration and the numbers in the dots represent the order of the fixations” (Tobii Pro, 2016, p. 73). Heat Map data is a different type of visual representation that “uses different colours to show the number of fixations participants made in certain areas of the image or for how long they fixated within that area” (Tobii Pro, 2016, p. 66). For example, red (hot) is used to indicate a high number of fixations or fixations that last relatively long. The analysis was performed by constructing a visual matrix with a composite of four output images for each kanji (Group 0 pre-semester, Group 0 post-semester, Group1 pre-semester, Group 1 post-semester). The purpose of generating a visual matrix for data analysis is to allow for possible comparisons between the following data sets in this study: (1) Group 0 PRE and POST, to monitor changes specific to this group (2) Group 1 PRE and POST, to monitor changes specific to this group, (3) Group 0 POST and Group 1 PRE, to compare how the variable of time or LX exposure might have manifested in Group 0 without using ICA Exercises, and (4) Group 0 POST and Group 1 POST, to determine the extent to which each group shows evidence of specific processing changes. Figure 27 below shows a sample of a visual matrix showing Gaze Plot images.

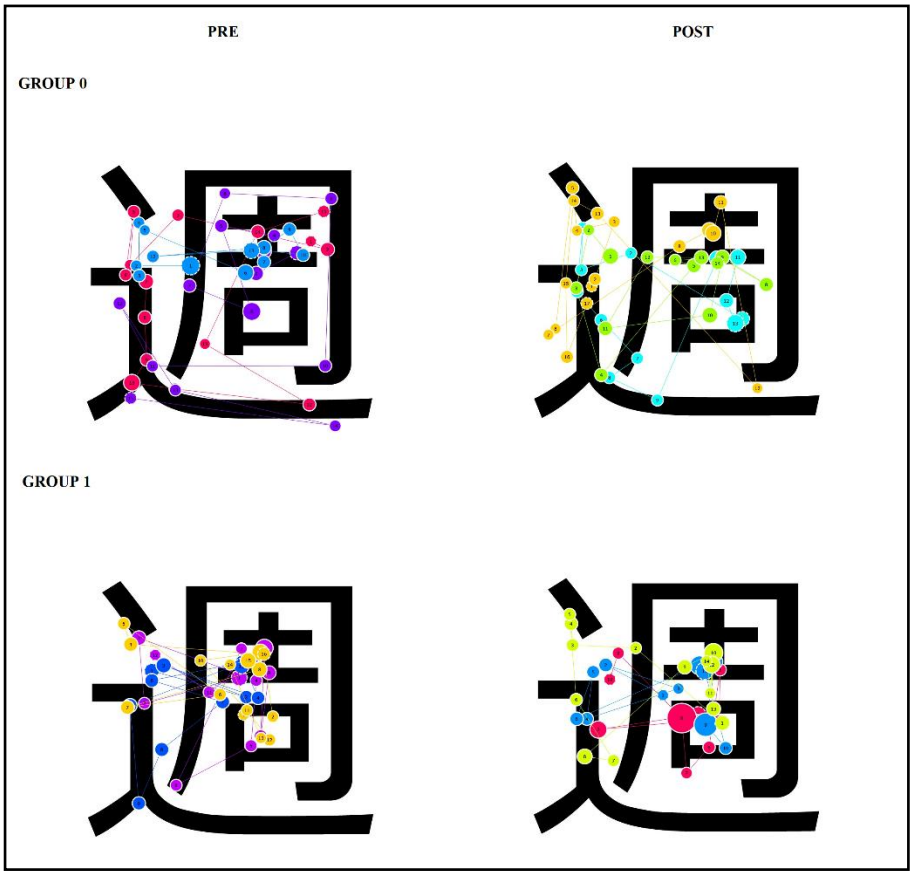



*Figure 27: Example of eye-tracking Gaze Plot data in visual matrix format*

Analysing the Gaze Plot data in a visual matrix involves tracking changes using two main indicators. Those are (1) the distribution of individual fixation points and (2) the size of individual fixation points. Tracking the distribution of individual fixation points provides a more detailed picture of precisely where the gaze is focused within the Area of Interest itself. This is useful for identifying qualitative differences between readings of two different time points or as a comparison across groups. Whereas measuring fixation times within an AOI provides an understanding of the overall cognitive load for that AOI, observing the distribution of points within the AOI could reveal specific details about the qualitative nature of the processing mechanism. The other indicator, the size of individual fixation points, can be tracked by examining the size of the circles in the overlay of the image. This could also be useful as a way to understand which specific strokes or points within an AOI received more or less attention (i.e. longer time) than other areas. Again, it provides insights into qualitative processes that would not be evident from an overall time measurement, such as mean fixation time.

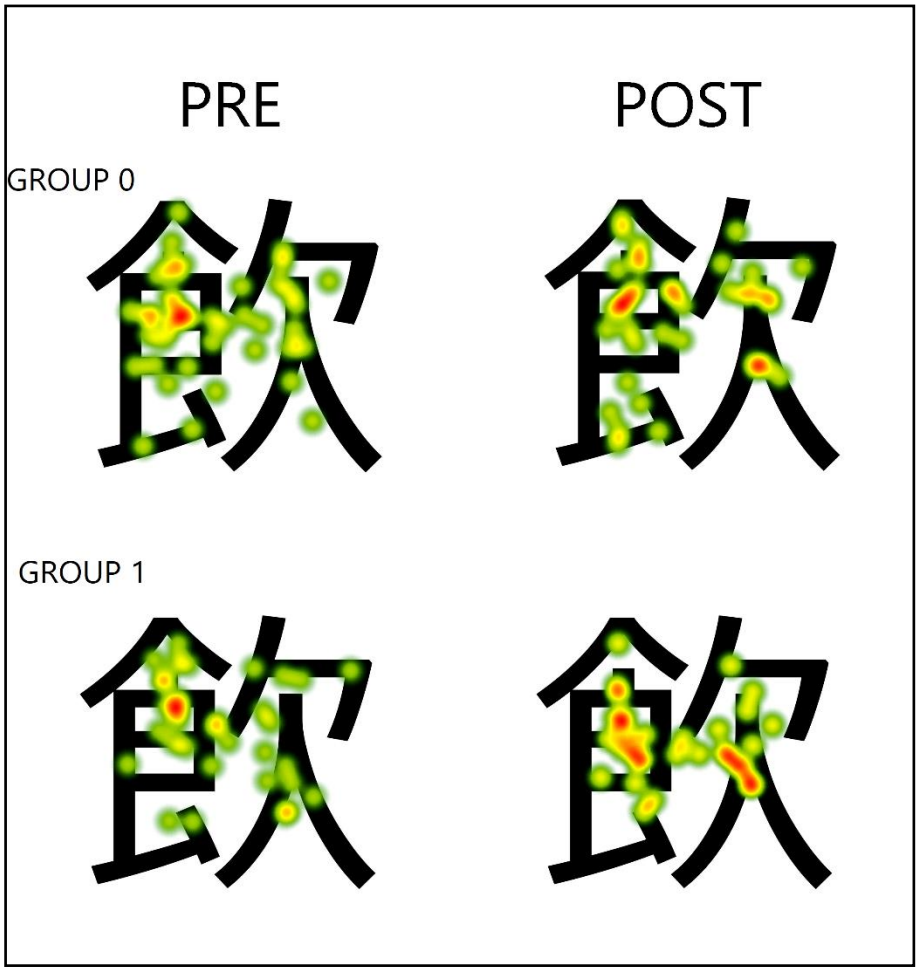



*Figure 28: Example of eye-tracking Heat Map data in visual matrix format*

Figure 28 above shows a sample of a visual matrix showing Heat Map images. Analysing Heat Map data using a visual matrix also allowed for a comparison of images between both groups pre-semester and post-semester. The analysis consisted of performing multiple passes at the images, noting any patterns, differences, similarities, or anything of interest in each image. As with the Gaze Plot data, the analysis was performed by tracking the indicators of distribution and intensity. Distribution can be tracked by simply identifying any notable changes in how the points are spatially arranged in the output images. The intensity is indicated by colour, with increasing intensity being represented as progressively deeper colours from green to yellow to red. This can show specific patterns about where within an AOI the gaze was focused and how intense the focus was on that specific point. Due to the limited sample size in this study, the visualization of data is intended to be used in conjunction with other data sets to provide a more complete picture of what types of trends are evident in the samples.

## 6.5 Kanji writing error analysis

### 6.5.1 Overview

This section describes the use of kanji writing error analysis as a method of establishing and understanding the nature of any changes observed in the kanji processing of participants over the 12-week data collection period. As discussed in Chapter 2, writing error analysis has been used effectively as a proxy measurement of cognition, allowing for insights into how kanji are being processed without the need for direct measurement from brain scans. Typically, findings show that at lower kanji proficiency levels, writing errors by LX learners are generally non-kanji type errors, in which the written attempt contains an erroneous combination of components or strokes that does not conform to an existing kanji character. $L1^{morph}$ readers of Japanese, on the other hand, are more likely to make phonological-type errors.

### 6.5.2 Participants

Participants were two groups of 1st year Dublin City University students, both taking the same Japanese language module. 'Group 0' (totalling 17 students) were ab-initio learners with minimal or no kanji knowledge. 'Group 1' (totalling 9 students) were lower intermediate learners with approximately one year of previous kanji learning. For this portion of the data collection, all 26 participants submitted written kanji exercises that were used for the analysis.

### 6.5.3 Method

Kanji exercises were given to the participants as in-class tasks during Week 4, Week 8, and Week 12 of the semester. The exercises required the students to translate simple English sentences into Japanese, using kanji wherever possible in the translation. Students were asked to make a deliberate effort to use kanji wherever the target translation contained characters that had already been learned on the syllabus. This was done to discourage the participants from using kana as a fallback in cases where they did not feel confident about writing the kanji character correctly. It was emphasised that the exercises were not part of any official assessment within the module, allowing the students to

freely make written attempts without the worry of any mistakes being penalised or reflecting badly on their academic performance. Students were given ample time in class to complete the activity so that their written attempts would not be hindered by time pressure.

This portion of the study uses an adaptation of the analytical framework used by Hatta et al. (1998) to carry out the analysis. In that study, the authors collected samples of kanji writing errors and divided the errors into ten separate categories. The main categories were P-Type ("substitution by a same reading or phonological kanji"), O-Type ("substitution by a configurational and orthographically similar kanji"), S-Type ("substitution by semantically-similar kanji"), and other permutations of these types. There were also NK-Type ("substitution by Non-Kanji") and Others (any other type of error). Assigning each error to a particular category allowed the authors to postulate a processing model that described the underlying cause of the errors. This thesis uses a simplified version of their framework, using five main categories corresponding to the P-Type, O-Type, S-Type, NK-Type, and Other-Type described above. Table 10 shows the categories of errors used in this study, together with the characterisation of those errors and actual examples from the participants.

*Table 10: Kanji writing error categories and examples*

| **Name** | **Characterization** | **Example** |
|---|---|---|
| P type | substitution by a same reading or **phonological** kanji | use of 気 (ki) in 季節 (kisetsu) |
| O type | substitution by an **orthographically** similar kanji | use of 米 instead of 来 |
| S type | substitution by a **semantically** similar kanji | use of 中 instead of 間 |
| NK type | substitution by a non-kanji | In 古, top and bottom reversed |
| Other | others | 米 instead of 語 |

Each instance of a kanji writing error from Weeks 4, 8, and 12 was assigned a category above. This allowed for a comparison of the frequency of incidence for different types of writing errors over the course of the module. It also allowed for a comparison of the error types and rates between Group 0 and Group 1. The errors were converted to table format and imported to Microsoft Excel. Mean

values and percentage values were calculated for each category over the three different time points and two groups.

A refinement of the above framework was devised for the analysis of Non-Kanji (NK) Type errors only. These errors were numerous and contained many different variations. While some written attempts did not resemble any kanji, others contained a strong resemblance to the target character but had minor errors that still rendered it a 'Non-Kanji' because technically, the written attempt was not an existing kanji character. Placing these two kinds of errors in the same category seemed to be sub-optimal since the latter attempt could be seen to be a much more accurate (if still incorrect) attempt. To gain further insights into the qualitative nature of these errors, it was decided to divide the NK-Type category into ten further sub-categories. Each of these ten sub-categories had specific characteristics that can potentially provide an understanding of how and why these types of errors were made. Table 11 shows these ten sub-categories with characterisations and actual examples from the participants.

*Table 11: Non-Kanji (NK) errors in ten sub-categories*

| | Name | Characterization | Example |
|---|---|---|---|
| **8a** | NK-Type | stroke too long | in 売 the bottom part of 士 is too long |
| **8b** | NK-Type | stroke too short | in 虫 the vertical stroke starts from 口 |
| **8c** | NK-Type | stroke wrong direction | use of 言 with the top stroke right to left |
| **8d** | NK-Type | correct components misplaced | in 前, the bottom two components are reversed |
| **8e** | NK-Type | use of one incorrect component | use of 扌in the left part of kanji 北 |
| **8f** | NK-Type | use of several incorrect components | use of 己, 厶 and 田 as one kanji |
| **8g** | NK-Type | component missing stroke(s) | use of 貝 with one horizontal stroke missing |
| **8h** | NK-Type | component has additional stroke(s) | use of 、 with 手 |
| **8i** | NK-Type | non-component (several incorrect strokes) | use of 食 with several strokes missing |
| **8j** | NK-Type | missing component | use of 言 hen with no other component |

This refinement of the Hatta et al. (1998) framework highlights the qualitative nature of writing errors in more detail and can provide further information on how the characters are being processed. The aim of this type of analysis was to describe the Non-Kanji Type error in more detail, paying attention to specific compositional features such as stroke length, stroke direction or orientation, instances of missing or additional strokes, incorrect use of components, etc. The main reason for including this further level of analysis was to understand the magnitude of the errors. For

example, a slightly misplaced stroke in an otherwise correct written representation can be considered a more accurate attempt than a character that is missing entire components or several strokes. This level of detail is a useful means of assessing how close the error was to being correct and determining if there are any specific patterns in the nature of the Non-Kanji Type errors. These errors were analysed in the same way as the main categories above, i.e. by assigning each error a category and documenting its occurrences over the course of the 12-week module for each group.

## 6.6 Student feedback survey

### 6.6.1 Overview

The aim of the student feedback survey was to answer RQ1c (*What issues are highlighted by kanji learners who use 'component analysis' materials?*). This is important because it can allow for an understanding of the issues that might impact the successful implementation of component analysis teachings materials, based directly on the responses of learners who used the materials. Answering the wider question of whether component analysis is an effective strategy for learning kanji is ultimately dependent on it being deployed correctly in teaching materials. While aspects such as student motivation and attitudes to kanji study must be included in an overall definition of its potential effectiveness, this survey aimed to understand the specifics of how users evaluated key practical factors such as workload, engagement with the materials, and perceived effectiveness of the tasks involved. It is hoped that collecting this kind of data will allow for an understanding of factors that influence the successful use of component analysis materials and how to maximize its potential in future iterations of teaching materials. See Appendix J for a complete list of the survey questions.

### 6.6.2 Participants

A total of 19 participants from the same cohorts responded, with 8 from Group 0 (ab-initio) and 11 from Group 1 (lower-intermediate).

### 6.6.3 Method

After the completion of the 12-week semester, participants were invited to complete an online survey that focussed on the kanji exercises delivered in the Intra-Character Awareness Exercises. The survey contained four sections. Sections 1-3 consisted of one section for each of the three exercise types in ICA. The questions in these sections used a 7-point Likert scale. The questions asked for responses that related specifically to the themes of workload, enjoyment, and perceived effectiveness of the exercises. Participants rated each exercise type accordingly. These themes were chosen to gain an understanding of the practical issues that could influence the successful use of component analysis teaching materials. For the purposes of this analysis, the definition of these terms is as follows: 'Workload' is defined as the number of tasks in an exercise or the cumulative effort or time required to complete those tasks. It is generally intended to reflect how much of the learner's time is occupied in the completion of the tasks. 'Enjoyment' is broadly defined as a measure of how positively the learner engaged with the materials and derived satisfaction from them. 'Perceived Effectiveness' is defined as the degree to which a learner believes that the tasks will produce tangible and beneficial changes in the trajectory of their own learning process. Section 4 of the survey was an open-ended section that allowed the participants to offer unstructured feedback, comments, and suggestions in their own words and in as much detail as they wished. This was done to give participants an opportunity to mention any other issues or offer opinions on topics that were not covered in the closed-ended questions of Sections 1-3.

The two types of data above were analysed in different ways, with the quantitative data from Sections 1-3 being matched directly to defined themes and the qualitative data from Section 4 being coded and categorized to the same themes. The Likert-scale data from Sections 1-3 matched specific questions in the survey to the three themes defined above. For example, responses to the propositions "These exercises could be finished quickly" and "These exercises were easy to understand" were used to generate a graph on workload (see Figure 45 in Section 7.4.2). Likewise, responses to the propositions "I enjoyed doing these exercises" and "These exercises were interesting" were used to generate a graph on enjoyment. The remaining propositions were matched

to perceived effectiveness since they related to subjective evaluations of how beneficial the respondent believed the exercises to be. The responses from Section 4 (unstructured feedback) were presented separately and not pooled together with the Likert-scale data in Sections 1-3. Therefore, in this study, it was not necessary to calculate Cronbach's Alpha as a measure of the internal consistency and reliability of the data sets.

The data from Sections 1-3 underwent an initial pre-analysis sorting. It was first imported to Microsoft Excel. Likert-scale data from all questions was converted to a low-to-high scaling system, where a low score indicated a low level of workload, enjoyment or perceived effectiveness, and a high score indicated a high level of the same. For example, participants were asked to respond to the statement "These exercises could be finished quickly" by selecting from '1' (strongly disagree) to '7' (strongly agree). A response of '2' would indicate that the participant found that the exercise had a high workload. Such responses were inverted so that all answers reflected the content of the response in the same low-to-high scaling system. The data was then imported to IBM SPSS 24, assigning different labels to participants from Group 0 and Group 1. Three sets of independent samples t-test were performed (one per survey section) in order to establish whether there were significant differences in responses between Group 0 and Group 1 for each question. A confidence interval of 95% was set for each of the tests. Since no significant differences were found to exist across groups, the data from both groups was aggregated. See Appendix M for the results of the t-tests. Following this, a series of frequency statistics were generated, displaying the overall mean values for responses to each question.

The data from Section 4 of the survey (open-ended questions) was analysed in Nvivo 12 Pro using the same 6-step thematic analysis (Braun & Clarke, 2006) outlined in Chapter 4. Responses were assigned to the above thematic categories of workload, enjoyment, and perceived effectiveness where appropriate. In addition, responses were manually coded with labels of 'positive' or 'negative' for the purposes of understanding whether the response included explicit approval or

disapproval of a particular aspect of the exercise. It was anticipated that this could provide insights into aspects of the materials that might influence the implementation of component analysis materials. Findings are presented in Chapter 7 and discussed in Chapter 8.

# 7 PHASE 2: Findings

## 7.1 Introduction

This chapter presents the findings from the three stages of data collection and analysis carried out in PHASE 2 of the study. Section 7.2 presents the findings from the eye-tracking portion of the study. This is followed by Section 7.3, which presents the findings from the kanji writing error analysis. Section 7.4 presents the findings from the student feedback survey about the Intra-Character Awareness exercises, with the aim of understanding possible issues that might impact the use of component analysis in teaching materials. Bringing these three data sets together, the overall aim of PHASE 2 was to quantify changes in kanji processing by the learners, to understand and explain the nature of those changes, and to identify what practical issues could influence the use of the materials involved.

## 7.2 Eye-tracking

This section presents the findings of the eye-tracking portion of the study. Participants from Group 0 (ab-initio) and Group 1 (lower intermediate) volunteered for eye-tracking sessions pre-semester and post-semester. This produced four sets of data for analysis (Group 0 PRE, Group 0 POST, Group 1 PRE, Group 1 POST). Three types of metrics are presented in the findings. They are (a) fixation time spent on each AOI or AOI category, measured in milliseconds, (b) Gaze Plot data displayed in a visual matrix, and (c) Heat Map data displayed in a visual matrix. For data type (a), fixation time, a total of eight Paired Sample t-tests were performed (four on each group) in order to compare the mean values of fixation times on specific AOI categories. In addition, both mean and sum times are represented in graph format. It should be noted that the AOI categories '*nyo*', '*tare*', and '*kamae*' were removed from analysis for this data type due to data skew resulting from the low number of individual AOIs for those categories relative to the other categories. For data types (b) and (c), a visual matrix was used to perform passes on the output images and document any

emerging trends or conspicuous phenomena. The three data types are intended to be triangulated and considered in tandem with other data sets due to the small sample size involved.

### 7.2.1 Fixation times

#### 7.2.1.1 Statistical tests

Table 12 below shows the findings of four sets of Paired Sample t-tests. The tests were performed on Group 0 (ab-initio learners) in order to identify whether there were any statistically significant differences between the mean values recorded pre-semester and those recorded post-semester for the AOI categories listed. The tests were conducted with a Confidence Interval of 95%.

*Table 12: Group 0 paired samples t-test findings*

**Group 0 - Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Lower | 95% Confidence Upper | | | |
| Pair 1 | hen_pre - hen_post | 2.46 | 2.01 | 0.90 | -0.04 | 4.95 | 2.73 | 4.00 | 0.05 |
| Pair 2 | tsukuri_pre - tsukuri_post | -5.91 | 4.65 | 2.08 | -11.68 | -0.13 | -2.84 | 4.00 | 0.05 |
| Pair 3 | kanmuri_pre - kanmuri_post | -0.94 | 1.47 | 0.66 | -2.77 | 0.89 | -1.43 | 4.00 | 0.23 |
| Pair 4 | ashi_pre - ashi_post | 0.01 | 2.65 | 1.19 | -3.29 | 3.30 | 0.01 | 4.00 | 0.99 |

Group 0 shows a statistically significant ($p \leq 0.05$) increase in the mean values of the '*tsukuri*' AOI between pre-semester and post-semester recordings. They also showed a statistically significant ($p \leq 0.05$) reduction in the mean values of the '*hen*' AOI between pre-semester and post-semester recordings. Although there were some differences in the other categories of '*kanmuri*' and '*ashi*', the mean fixation times did not fall within a statistically significant range for these tests.

The same tests were performed on Group 1 (lower intermediate learners), and the findings are shown in Table 13 below.

*Table 13: Group 1 paired samples t-test findings*

| Group 1 - Paired Samples Test | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Paired Differences | | | | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Lower | 95% Confidence Upper | t | df | Sig. (2-tailed) |
| Pair 1 | hen_pre - hen_post | -1.57 | 2.38 | 1.07 | -4.53 | 1.39 | -1.47 | 4.00 | 0.21 |
| Pair 2 | tsukuri_pre - tsukuri_post | -1.94 | 2.36 | 1.06 | -4.88 | 0.99 | -1.84 | 4.00 | 0.14 |
| Pair 3 | kanmuri_pre - kanmuri_post | 0.60 | 2.23 | 1.00 | -2.16 | 3.37 | 0.61 | 4.00 | 0.58 |
| Pair 4 | ashi_pre - ashi_post | 1.03 | 1.28 | 0.57 | -0.56 | 2.62 | 1.80 | 4.00 | 0.15 |

Although there are differences between the mean values of pre-semester and post-semester, none of the categories showed a statistically significant difference for these tests. The findings for the '*tsukuri*' (p=0.14) and '*hen*' (p=0.21) AOI categories can be considered notable in that both showed an increase in mean values from pre-semester to post-semester, although they fall outside the 95% Confidence Interval.

#### 7.2.1.2 Mean and sum fixation times

Figure 29 below shows the sum values of fixation times for Group 0 at the time points 'PRE' (Pre-Semester) and 'POST' (Post-Semester) for the listed AOI categories, measured in milliseconds.

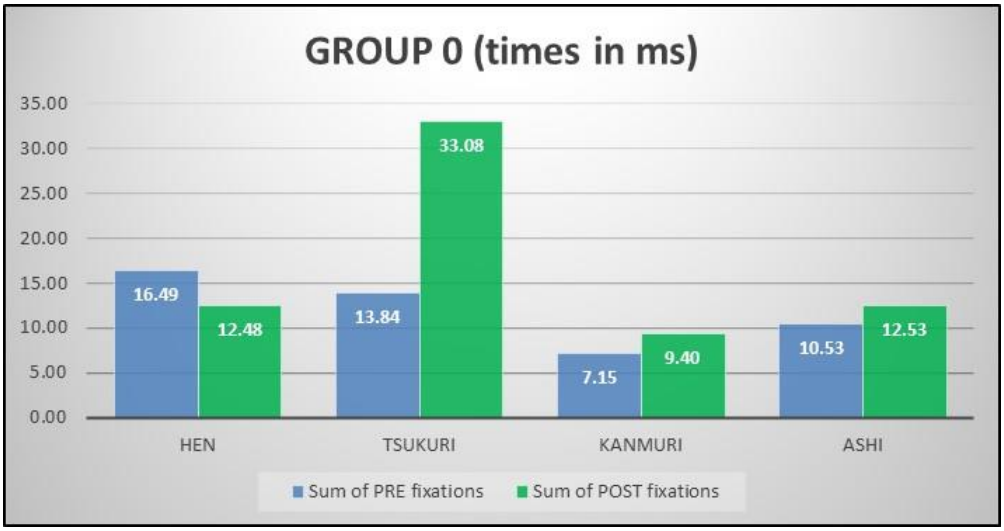



*Figure 29: Group 0 sum fixation times*

Figure 30 below shows the mean values of fixation times for Group 0 at the time points 'PRE' (Pre-Semester) and 'POST' (Post-Semester) for the listed AOI categories, measured in milliseconds.

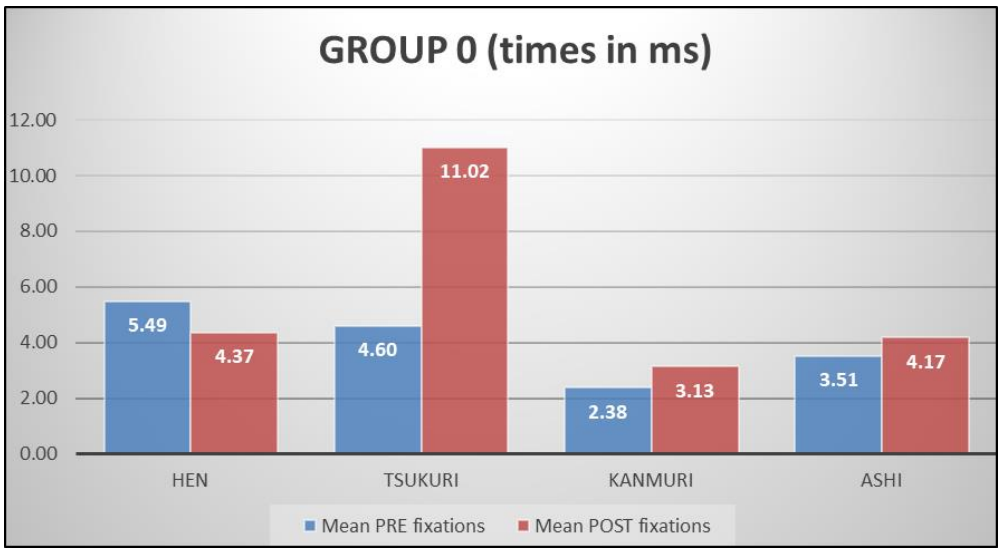



*Figure 30: Group 0 mean fixation times*

Both Figure 29 and Figure 30 above show the same trend for each AOI. There is a reduction in the '*hen*' AOI, a large increase in the '*tsukuri*' AOI, a slight increase in the '*kanmuri*' AOI, and a slight increase in the '*ashi*' AOI.

Figure 31 and Figure 32 below relate to Group 1, with both Sum fixations and Mean fixations shown for both time points 'Pre- Semester' and 'Post-Semester'. Figure 31 shows the sum values of fixation times for Group 1 at the time points 'PRE' (Pre-Semester) and 'POST' (Post-Semester) for the listed categories, measured in milliseconds.

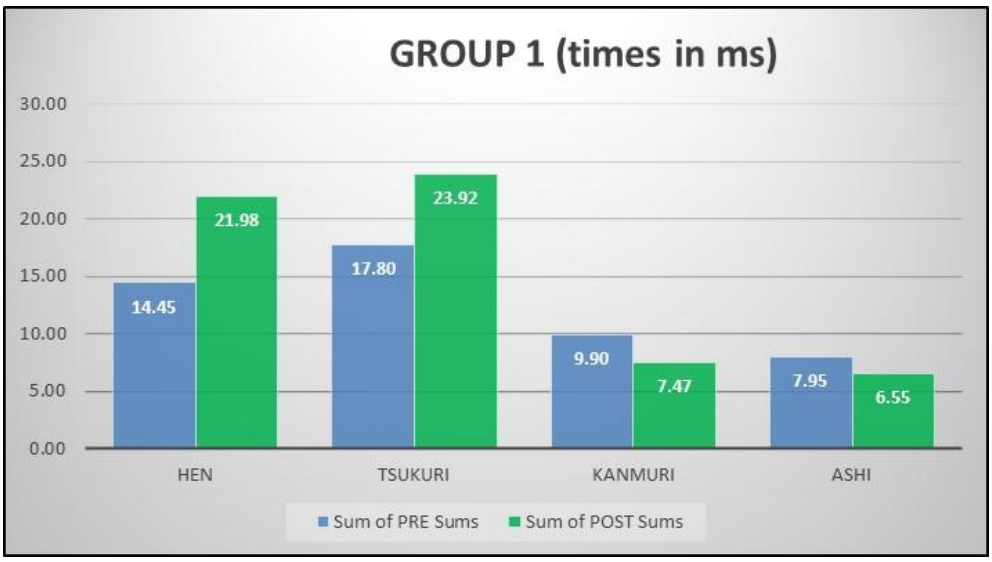



*Figure 31: Group 1 sum of fixations*

Figure 32 below shows the mean values of fixation times for Group 1 at the time points 'PRE' (Pre-Semester) and 'POST' (Post-Semester) for the listed categories, measured in milliseconds.

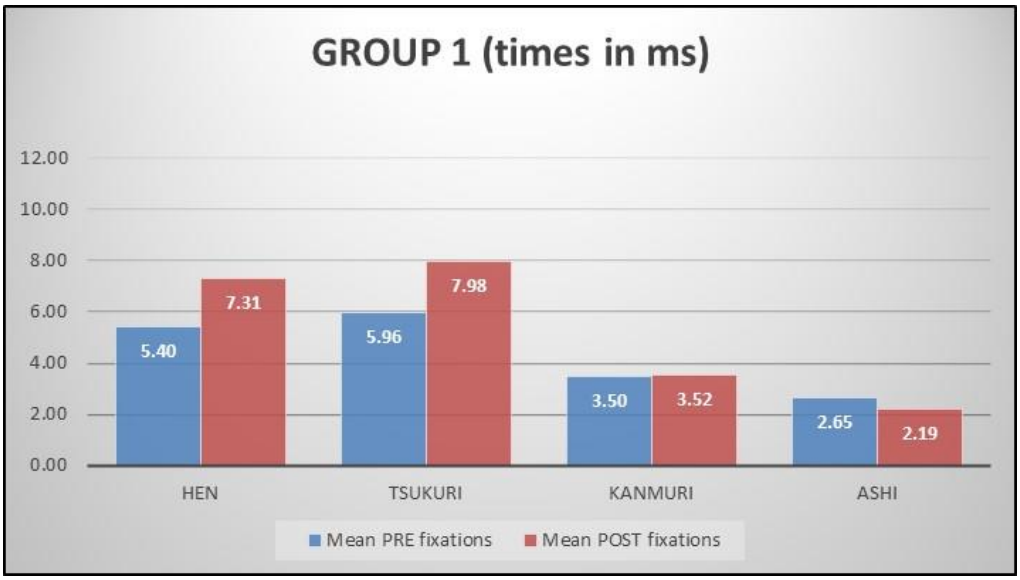



*Figure 32: Group 1 mean fixations*

Figure 31 and Figure 32 show similar patterns for Group 1. There is an increase in the '*hen*' AOI, an increase in the '*tsukuri*' AOI, and a slight reduction in the '*ashi*' AOI. For the '*kanmuri*' AOI, the sum times show a reduction, whereas the mean times are almost identical.

#### 7.2.1.3 Comparison of '*hen*' and '*tsukuri*'

Finally, in order to compare the two groups across AOI type, Figure 33 below shows the same findings presented with both groups together. The clearest differences appear in the '*hen*' and '*tsukuri*' AOIs, and for the purpose of clarity, only those AOIs are shown below.

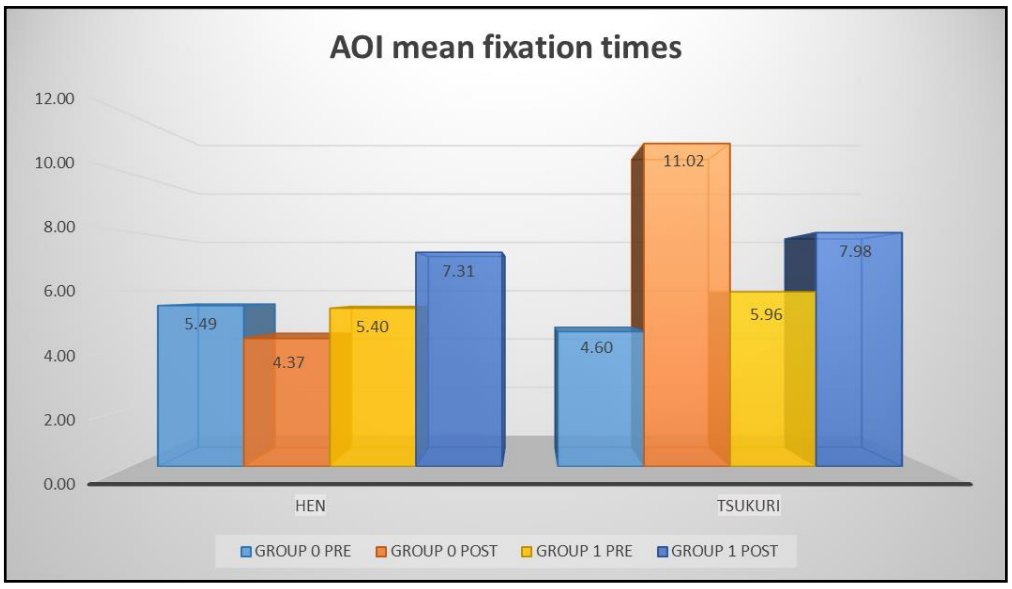



*Figure 33: Mean AOI fixation times by category and group*

For the '*hen*' AOI, a noticeable difference is that values for Group 0 decreased over time while values for Group 1 increased over time. For the '*tsukuri*' AOI, Group 0 shows a large increase over time, with the post mean of 11.02ms being greater than the post mean of 7.98ms for Group 1. Although Group 1 did show an increase over time, it was not statistically significant and not as dramatic as that of Group 0. The comparisons across groups for the '*kanmuri*' and '*ashi*' did not show any notable details.

### 7.2.2 Gaze Plot

Gaze Plot data was analysed by constructing a visual matrix of output images, consisting of a composite of four images. The images used for each kanji character were Group 0 PRE, Group 0 POST, Group 1 PRE, and Group 1 POST. These were aligned to allow for comparisons of the data across groups and between time frames.

#### 7.2.2.1 Fixations on '*hen*' and '*tsukuri*' AOIs

In general, the Gaze Plot data for both groups tends to confirm the main trend seen in the fixation data, i.e. that Group 0 shows a reduction in fixations on '*hen*' and an increase in '*tsukuri*', while Group 1 shows an increase in both '*hen*' and '*tsukuri*'. Figure 34 below shows a typical spread of fixations in the data from both groups. For Group 0, there is a reduction in the number and magnitude of fixations from the 日 '*hen*' radical (positioned on the left) in the POST reading relative to the PRE reading. At the same time, there is an increase in the number of fixations on the '*tsukuri*' component (positioned on the right). For Group 1, there appears to be a larger magnitude of fixations (represented by larger circles) on the 日 '*hen*' radical in the POST reading, as well as a large increase in the magnitude of fixations on '*tsukuri*' in the POST reading. This pattern was seen in multiple images, mirroring the pattern seen in the fixation data.

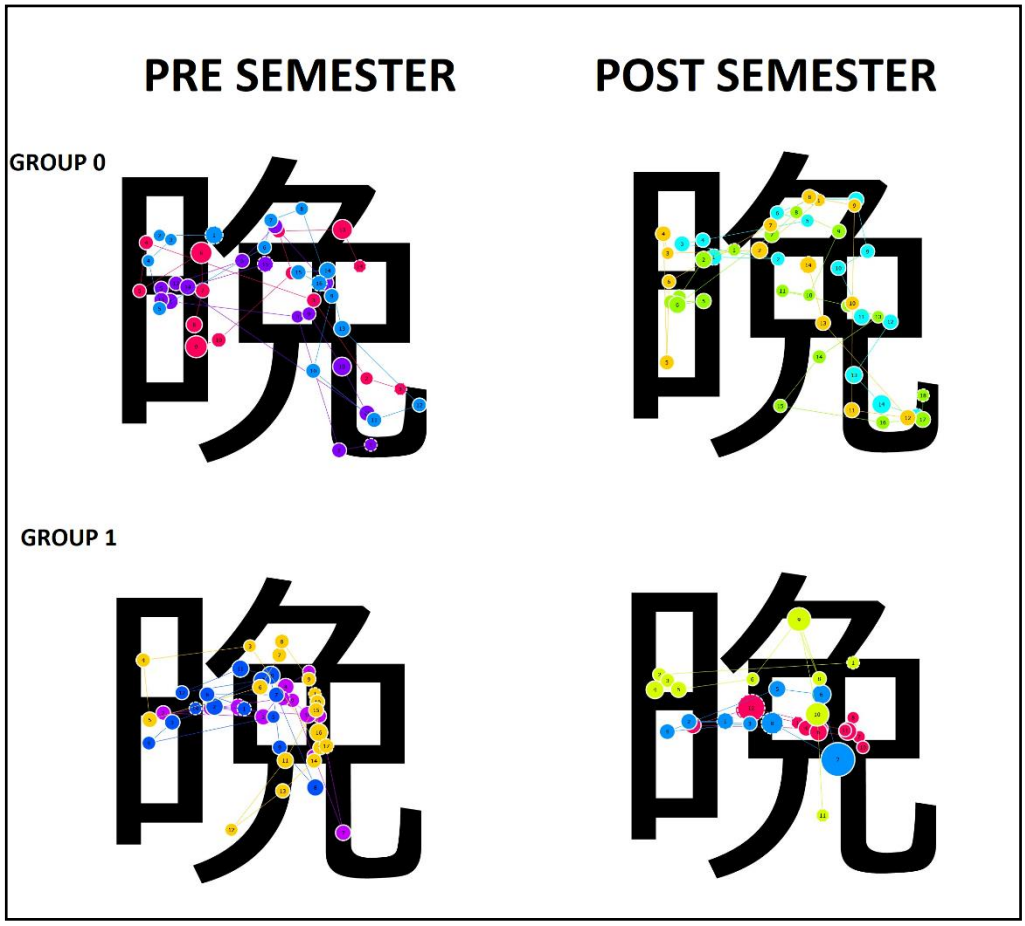



*Figure 34: Typical trend for 'hen' and 'tsukuri' AOI*

#### 7.2.2.2 ‘Diffuse’ gaze for Group 0

Another trend that emerged from the visualization of the data relates to the breadth of distributions seen in the Group 0 data. The Group 0 POST readings show a more ‘diffuse’ gaze than the Group 0 PRE readings. The term ‘diffuse’ is used here to express the idea of a wider spread of individual points of fixation within a component or character. There are multiple instances in the data whereby the PRE data shows a concentration of fixations that roughly corresponds to the central vertical axis of a component. The POST data shows that the above pattern changes to a wider spread of fixations, extending out beyond the central axis to more peripheral parts of the component. This change from a higher to a lower concentration of fixations, which are spread wider than before, is more apparent in Group 0. Figure 35, Figure 36, and Figure 37 below show three examples of this ‘diffuse’ gaze in the POST readings of Group 0.

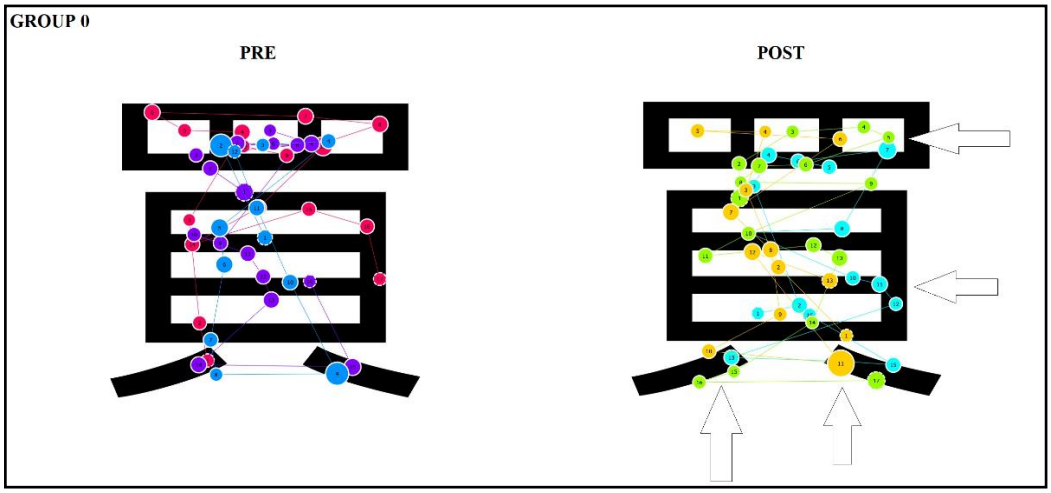



*Figure 35: Example 1 of 'diffuse' gaze in Group 0*

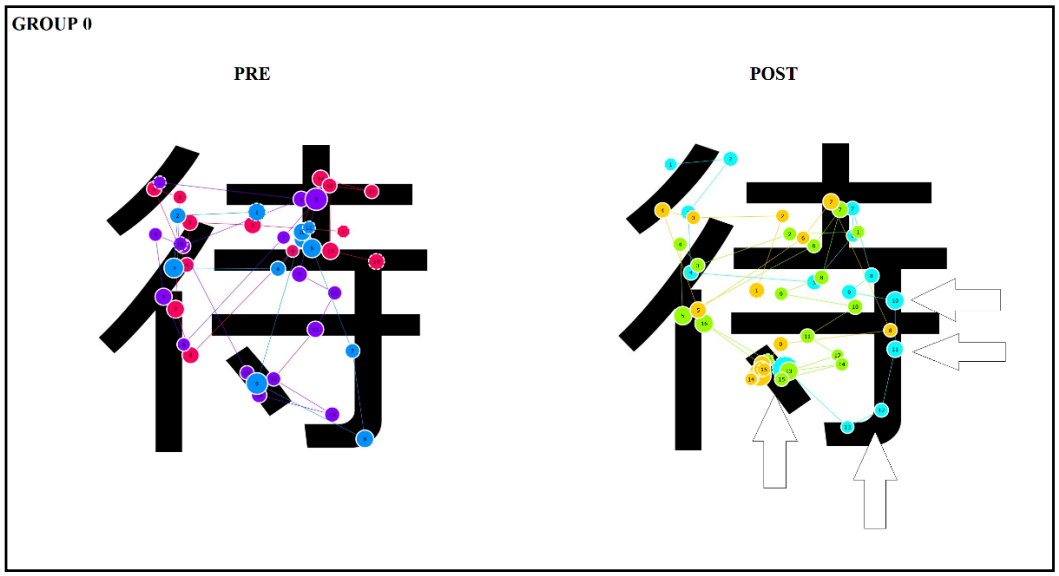



*Figure 36: Example 2 of 'diffuse' gaze in Group 0*

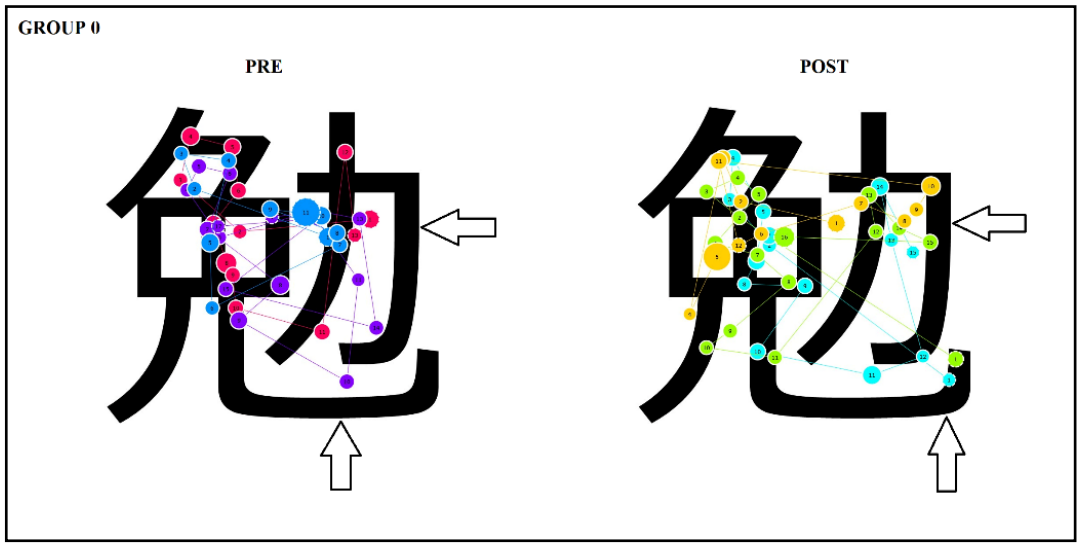



*Figure 37: Example 3 of 'diffuse' gaze in Group 0*

#### 7.2.2.3 Longer fixations on points

Group 0 also show a trend of longer fixations on individual points within components in the POST readings. This is represented graphically by the size of the circle. Smaller circles represent shorter fixations, while larger circles represent longer fixations on a specific point. Figure 38 below shows three examples of Group 0 POST readings that show this pattern in the data.

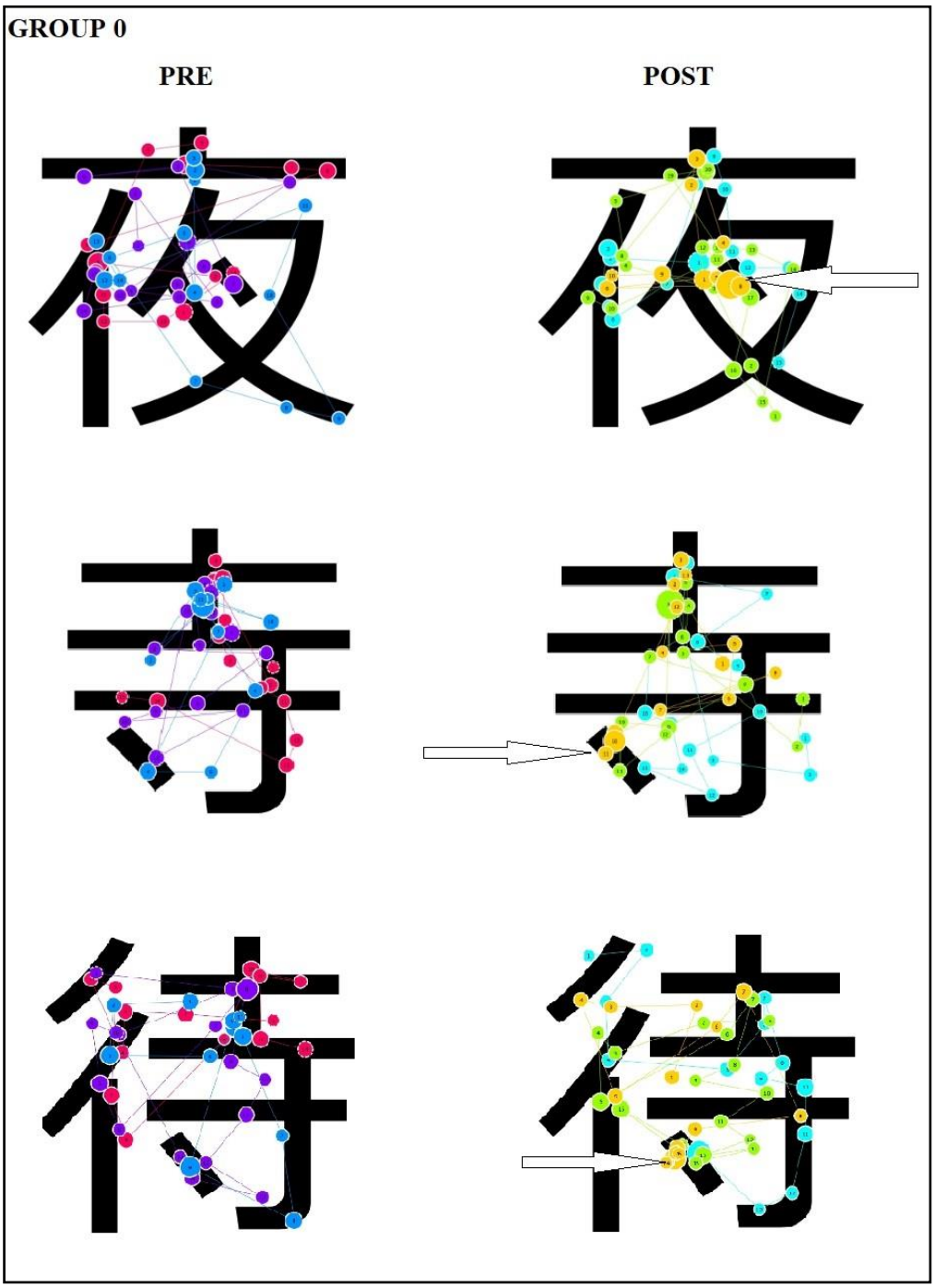



*Figure 38: Examples of longer individual fixations in Group 0 POST*

The white arrows point to instances of increases in the magnitude of fixations on specific orthographic points within components. In the case of the characters shown above, the fixations on

the ‘dot’ ( ◆ ) or short isolated stroke in the components are both more numerous and larger in the POST reading than in the PRE reading. This effect was not observed in the Group 1 readings.

#### 7.2.2.4 ‘Narrowing’ effect in enclosures

Both groups show evidence of a ‘narrowing’ effect in characters that contain an enclosed or a semi-enclosed component. A typical pattern can be seen in Figure 39 below. Both groups show a centralising ‘narrowing’ trend from PRE to POST, characterised by a change from more to less focus on the external enclosure component. This is more pronounced in Group 0 but appears to be a common feature in both groups. Chapter 8 briefly discusses the hypothesis that this effect is evidence that outer lines may be being processed more efficiently, perhaps being recognized in peripheral vision. The narrowing effect can also be detected on smaller individual strokes within the character. For example, in Figure 39 below, Group 0 shows a focus on the isolated ◆ stroke, with more fixations and longer times spent on it than PRE readings.

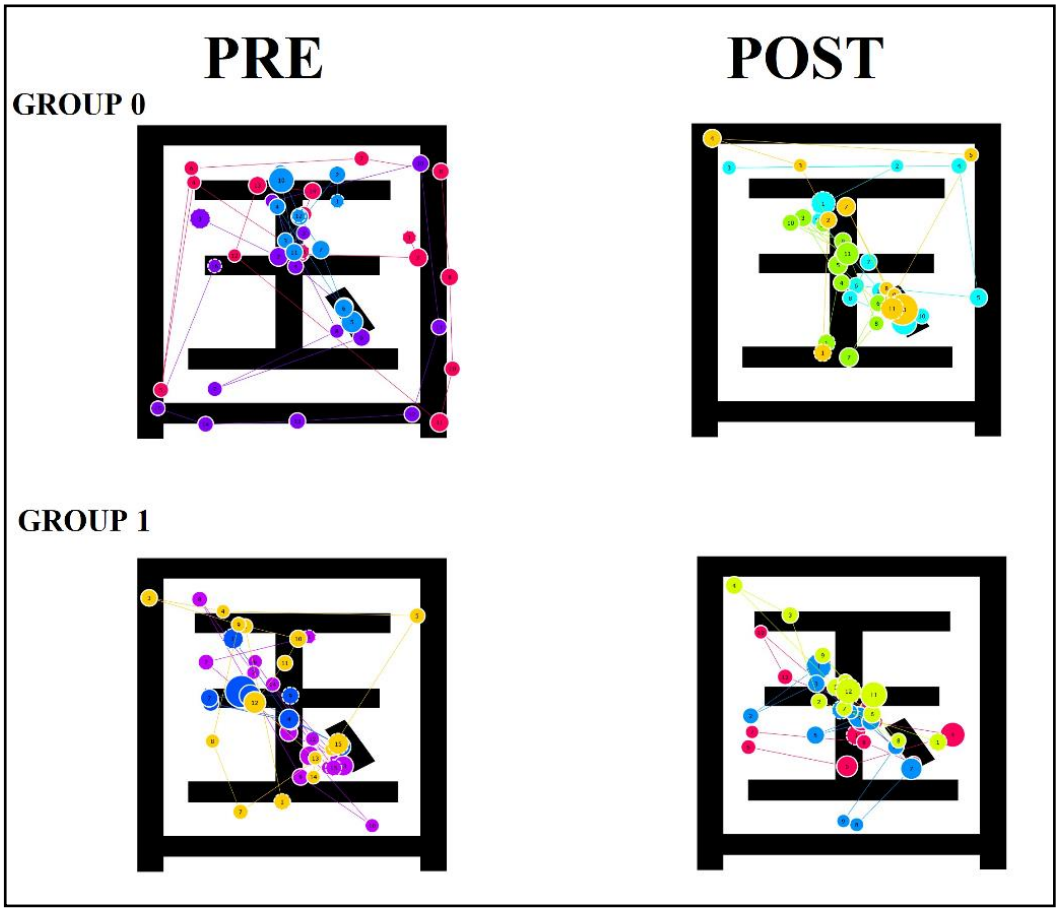



*Figure 39: Gaze Plot data showing 'narrowing' effect*

#### 7.2.2.5 Summary of findings by AOI category

Table 14 below shows a summary of the key findings from the Gaze Plot data, presented by group and by component type. The findings express the changes observed between the PRE and POST readings for that group.

*Table 14: Summary of Gaze Plot findings*

| Group | Component | Differences in PRE and POST readings |
|---|---|---|
| 0 | *hen* | Reduction in fixations. Shorter fixations. |
| 0 | *tsukuri* | Increase in fixations. Longer fixations. More 'diffuse' gaze within component.<br>Specific focus on individual lines and strokes. |
| 0 | *kanmuri* | Slight reduction in fixations. |
| 0 | *ashi* | No significant changes. |
| 1 | *hen* | Longer fixations. |
| 1 | *tsukuri* | Increase in fixations. Longer fixations. |
| 1 | *kanmuri* | Reduction in fixations. |
| 1 | *ashi* | No significant changes. |

### 7.2.3 Heat Map

This section presents the findings from the Heat Map data. There were five conspicuous patterns that appeared in the data, discussed in separate sections below with supporting examples from the data sets.

#### 7.2.3.1 Patterns in '*hen*' and '*tsukuri*' AOI

As with the Gaze Plot data, the Heat Map data shows a general trend that matches the overall fixation time data for the AOI categories '*hen*' and '*tsukuri*'. For Group 0, there appears to be a general decrease in gaze intensity in the '*hen*' AOI over time, while there is a general increase in the '*tsukuri*' AOI over time. For Group 1, there is a slight increase in the '*hen*' AOI over time and a moderate increase in the '*tsukuri*' AOI over time. Figure 40 below shows an example of a typical trend seen in the data for these AOI categories.

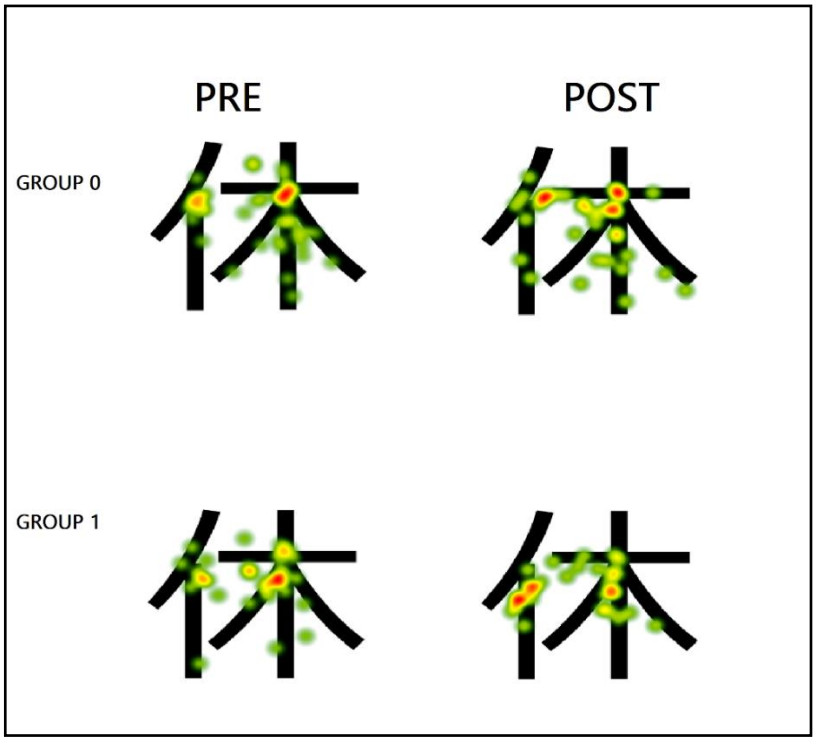



*Figure 40: General trend in 'hen' and 'tsukuri' AOI*

In the Group 0 readings, the yellow/red colouring on the left-positioned radical (亻) in the PRE reading represents a moderate to large gaze intensity. This changes to a group of green points in the POST reading, signifying a lower gaze intensity. There is also an accompanying shift in the right-positioned component (木), which is characterized by a general increase in yellow/red areas on that component, representing a general increase in gaze intensity for the area of the character. In the Group 1 readings, the same analysis indicates an increase in intensity for the left-positioned radical (亻) over time. In general, the readings from both groups on these AOIs are consistent with the fixation time and Gaze Plot data.

The Heat Map data also offers confirmation of the same ‘diffuse’ pattern of distribution for Group 0 that is seen in the Gaze Plot data. In Figure 40 above, the Group 0 POST image shows a wider spread of groupings on peripheral strokes. Figure 41 below shows another example.

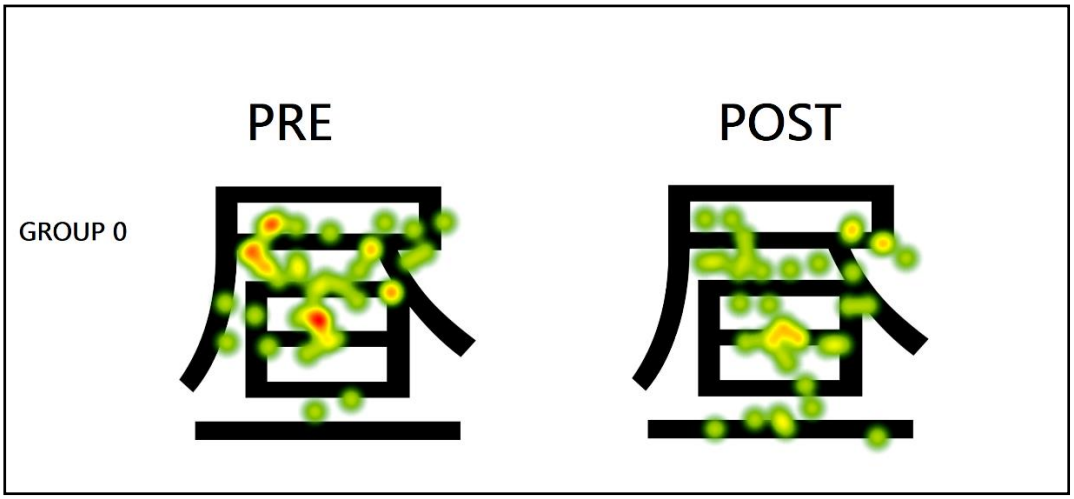



*Figure 41: Group 0 Heat Map 'diffuse' gaze*

In the POST reading, there is evidence of groupings that have a wider distribution on peripheral strokes.

#### 7.2.3.2 Group 0 'tracing' effect

One notable finding for Group 0 is that there is evidence of a targeted focus on individual lines and strokes in the POST data. It is not possible to discern such a pattern from the sum or mean fixation values, but it is more apparent in the visualization of data. The POST groupings in the Heat Map data appear to be more spread out and contain several instances of tracking specific points within a component. It can appear as a 'tracing' effect, whereby the data seems to show a tracing of lines or a concentration of fixations on a specific point within the component. Chapter 8 discusses the hypothesis that this 'tracing' effect along lines and strokes is evidence of increased compositional awareness. Figure 42 below shows a selection of the POST readings from Group 0 that show this focus on individual lines and strokes.

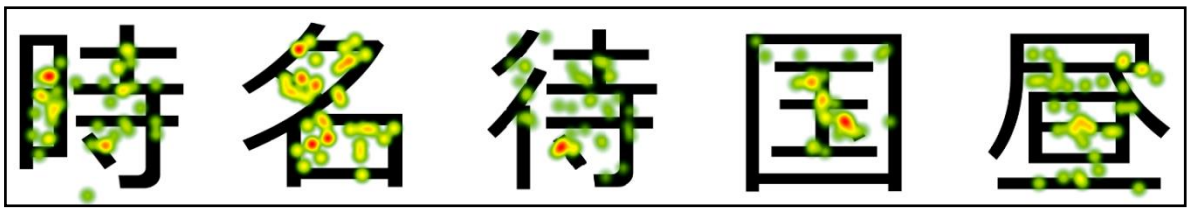


*Figure 42: Group 0 POST examples of 'tracing' effect*

#### 7.2.3.3 Group 1 'top-down' effect

The Heat Map data from Group 1 shows evidence of a slight decrease in focus on the '*kanmuri*' AOI or other characters that contain 'upper' and 'lower' components. This is characterized by a

general decrease in the number and intensity of ‘upper’ groupings over time. This ‘top-down’ effect appears as a general downward shift in the concentrations of Heat Map groupings. Figure 43 below shows four examples that highlight this effect.

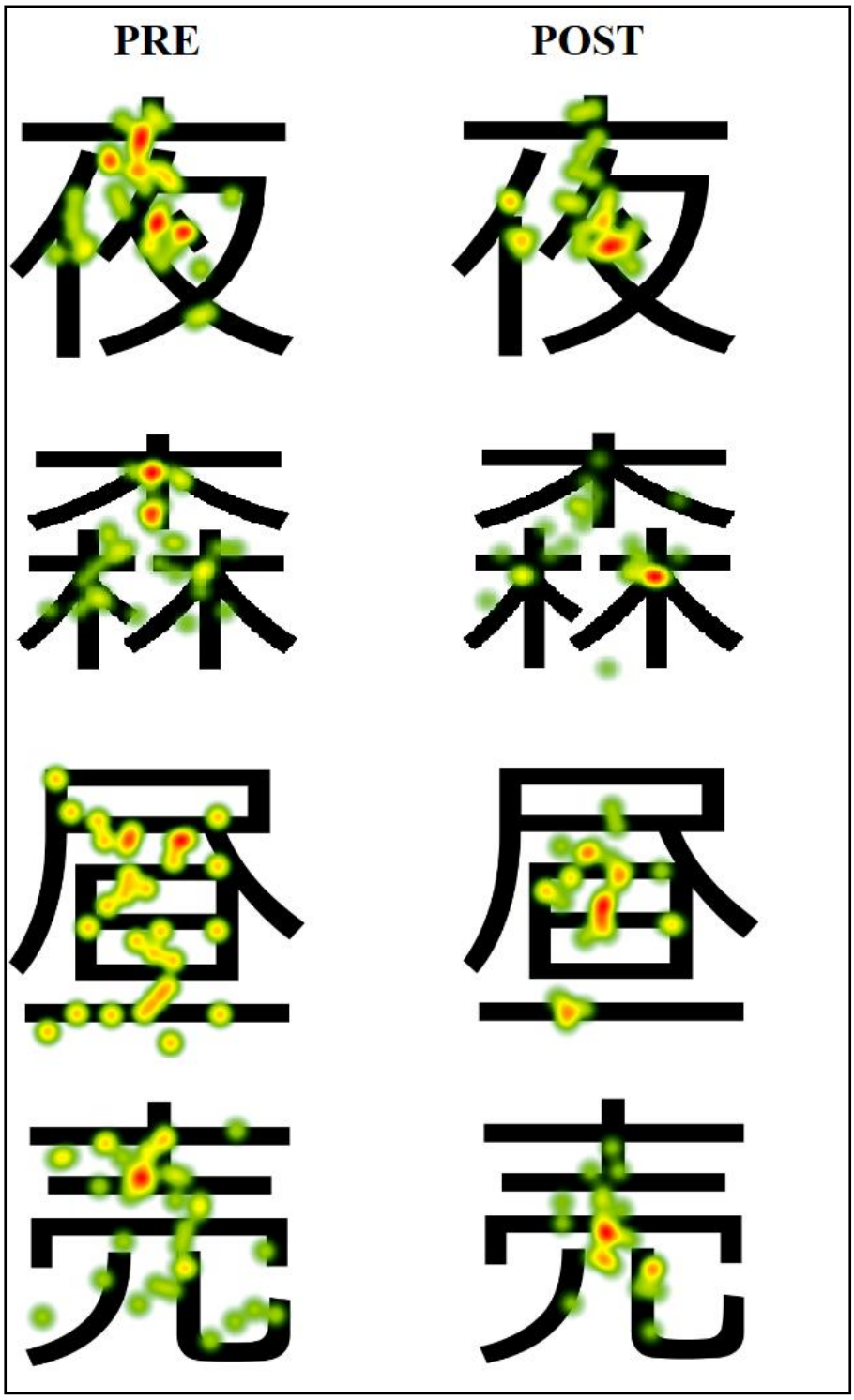



*Figure 43: Examples of ‘top-down’ shift in Group 1*

#### 7.2.3.4 Group 1 'centralized' gaze

Group 1 also show evidence of a 'centralized gaze' in both PRE and POST readings. This term is used with the intention to describe the effect of a concentration of focus along a central axis in a particular component. This is in contrast to the 'diffuse' spread mentioned above in that it shows a narrower band of focus that is generally centred on the vertical axis of a component. Although the effect is seen in both the PRE and POST readings, it appears to be slightly more noticeable in the POST readings. The effect is also present across kanji characters of different categories, irrespective of whether it was a left-right type or top-bottom type. Figure 44 below shows examples of this 'centralized gaze' in Group 1.

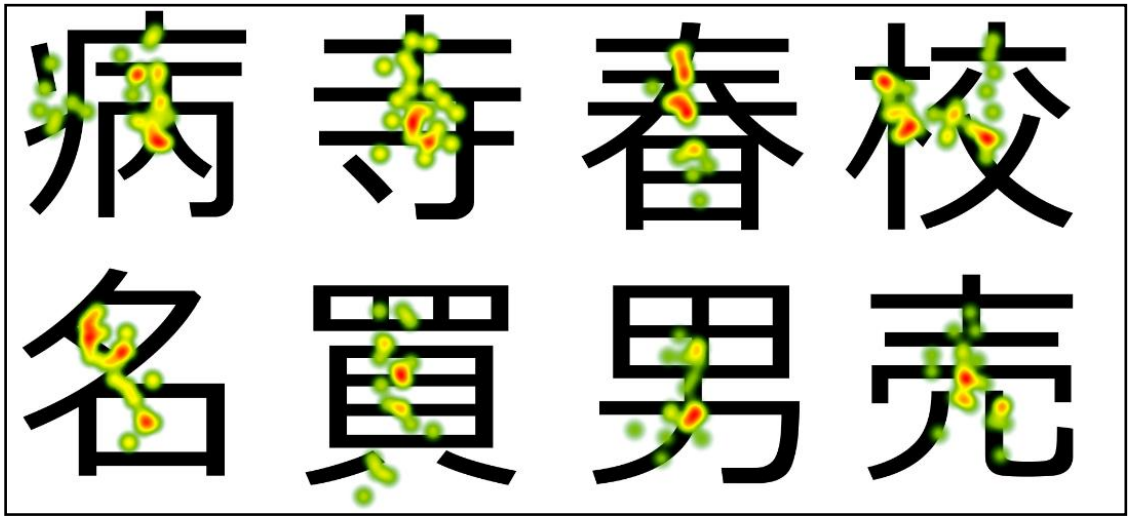


*Figure 44: Examples of 'centralized gaze' in Group 1*

#### 7.2.3.5 Summary of findings from Heat Map data

Table 15 below shows a brief summary of the findings from the Heat Map data, presented by group and by component type. The findings express the changes observed between the PRE and POST readings for that group.

*Table 15: Summary of Heat Map findings*

| Group | Component | Differences in PRE and POST readings |
|---|---|---|
| 0 | *hen* | Reduction in groupings. More diffuse spread. |
| 0 | *tsukuri* | Increase in groupings. More diffuse spread. Evidence of 'tracing' effect. |
| 0 | *kanmuri* | Inconclusive. |
| 0 | *ashi* | Inconclusive. |

| | | |
|---|---|---|
| 1 | *hen* | Increase in groupings. Evidence of 'centralized gaze'. |
| 1 | *tsukuri* | Increase in groupings. Evidence of 'centralized gaze'. |
| 1 | *kanmuri* | Evidence of 'top-down' shift. |
| 1 | *ashi* | Some cases of 'top-down' shift extending to lower positioned components. |

## 7.3 Kanji writing error analysis

Written work was collected from participants at Week 4, Week 8, and Week 12 of the semester. All kanji writing errors were first catalogued using an adapted version of the framework used in Hatta et al. (1998), simplified to focus on five specific types of error. The frequency of instances of these errors was compared over the course of the semester and across groups. To further understand the nature of these errors, the framework was refined to focus on 'Non-Kanji' errors, wherein the written reproduction does not conform to any existing kanji. This was done in an attempt to understand the qualitative aspects of the errors in more detail. For the analysis of these 'NK-type' errors, the refined framework focused on ten types of errors, with each NK error being assigned to one of those categories. Again, the frequency of instances of these errors was compared across the three time points during the semester. The findings from Group 0 and Group 1 are presented separately because there were clear differences in the distributions of error types between the groups.

### 7.3.1 Overall kanji writing error rates

#### 7.3.1.1 Group 0

Table 16 below shows the findings from kanji writing errors of Group 0, expressed as percentages of the overall number of errors for that time frame.

*Table 16: Group 0 overall kanji writing errors*

| GROUP 0 | Type 1 | Type 2 | Type 3 | Type 8 | Type 10 |
|---|---|---|---|---|---|
| | Phonological | Orthographic | Semantic | Non-Kanji | Other |
| WEEK 4 | 0.00 | 22.45 | 2.04 | 73.47 | 2.04 |
| WEEK 8 | 0.00 | 14.47 | 22.37 | 61.84 | 1.32 |
| WEEK 12 | 0.00 | 6.45 | 11.29 | 79.03 | 3.23 |

There we no instances of Type 1 (Phonological) errors at any time. There was an ongoing reduction of Type 2 (Orthographic) errors from 22.45% in Week 4 to 6.45% in Week 12. Type 3 (Semantic) errors showed a large increase from Week 4 (2.04%) to Week 8 (22.37%) but then a reduction to 11.29% in Week 12. The number of Type 8 (Non-Kanji) errors accounted for the majority of errors, with 73.47% in Week 4, a reduction to 61.84% in Week 8, and a subsequent increase to 79.03% in Week 12. Type 10 (Other) errors accounted for only a small portion of the errors.

#### 7.3.1.2 Group 1

Table 17 below shows the findings from kanji writing errors of Group 1, expressed in percentages of the overall number of errors.

*Table 17: Group 1 overall kanji writing errors*

| GROUP 1 | Type 1 | Type 2 | Type 3 | Type 8 | Type 10 |
|---|---|---|---|---|---|
| | Phonological | Orthographic | Semantic | Non-Kanji | Other |
| WEEK 4 | 0.00 | 39.13 | 8.70 | 43.48 | 8.70 |
| WEEK 8 | 8.00 | 12.00 | 12.00 | 68.00 | 0.00 |
| WEEK 12 | 2.94 | 11.76 | 11.76 | 73.53 | 0.00 |

Type 1 (Phonological) errors accounted for a relatively small amount of the total, with an overall slight increase from zero to 2.94%. There was a considerable reduction in Type 2 (Orthographic) errors from Week 4 (39.13%) to Week 8 (12%), stabilising at 11.76% in Week 12. Type 3 (Semantic) errors showed a slight increase from 8.70% to 11.76% overall. For Type 8 (Non-Kanji) errors, Group 1 had a much lower rate than Group 0 in Week 4, with NK errors accounting for 43.48% of the total. This increased to 68% in Week 8 and further increased to 73.53% in Week 12. Type 10 (Others) accounted for 8.70% of errors in Week 4, but no instances were recorded in Week 8 or Week 12.

### 7.3.2 Non-Kanji error rates

Table 18 and Table 19 below show both groups' error rates for the ten categories of the refined framework for analysing the Non-Kanji errors. The labels 8a to 8j describe the qualitative nature of the Non-Kanji error. The values shown in Week 4, Week 8, and Week 12 are expressed as percentages of the overall number of Non-Kanji type errors for each data set.

#### 7.3.2.1 Group 0

*Table 18: Non-Kanji errors by Group 0*

| | **GROUP 0 - NK type error** | | | |
|---|---|---|---|---|
| | (percentage of error by category) | **WEEK 4** | **WEEK 8** | **WEEK 12** |
| **8a** | stroke too long | 33.33 | 10.64 | 10.20 |
| **8b** | stroke too short | 5.56 | 6.38 | 14.29 |
| **8c** | stroke wrong direction | 2.78 | 17.02 | 18.37 |
| **8d** | correct components misplaced | 0.00 | 2.13 | 2.04 |
| **8e** | use of one incorrect component | 8.33 | 2.13 | 8.16 |
| **8f** | use of several incorrect components | 2.78 | 4.26 | 2.04 |
| **8g** | component missing stroke(s) | 19.44 | 21.28 | 10.20 |
| **8h** | component has additional stroke(s) | 2.78 | 2.13 | 4.08 |
| **8i** | non-component (several incorrect strokes) | 5.56 | 10.64 | 12.24 |
| **8j** | missing component | 19.44 | 23.40 | 18.37 |

There are several error types that show noticeable changes. Error type 8a (stroke too long) showed a large reduction from Week 4 (33.33%) to Week 12 (10.20%). Error type 8b (stroke too short) showed a slight increase from 5.56% to 14.29% overall. Error type 8c (stroke wrong direction) showed a moderate increase from Week 4 (2.78%) to Week 12 (18.37%). Another notable finding is a decrease in error type 8g (component missing strokes) from Week 4 (19.44%) to Week 12 (10.20%). Finally, error type 8i (non-component) showed a slight increase from Week 4 (5.56%) to Week 12 (12.24%). To summarize the findings relating to Non-Kanji type errors, Group 0 mainly showed changes in errors relating to stroke length and direction (categories 8a, 8b, and 8c). They also showed a reduction in error type 8g (component missing stroke) errors and a slight increase in 8j (non-component errors).

#### 7.3.2.2 Group 1

Table 19 below shows the Non-Kanji type writing errors by Group 1 in Week 4, Week 8, and Week 12. As above, the values are expressed as percentages of the overall number of errors of that type for that time point.

*Table 19: Non-Kanji errors by Group 1*

| | GROUP 1 - NK type error | | | |
|---|---|---|---|---|
| | (percentage of error by category) | WEEK 4 | WEEK 8 | WEEK 12 |
| 8a | stroke too long | 30.00 | 17.65 | 4.00 |
| 8b | stroke too short | 30.00 | 29.41 | 4.00 |
| 8c | stroke wrong direction | 0.00 | 0.00 | 0.00 |
| 8d | correct components misplaced | 0.00 | 0.00 | 0.00 |
| 8e | use of one incorrect component | 10.00 | 0.00 | 20.00 |
| 8f | use of several incorrect components | 10.00 | 0.00 | 0.00 |
| 8g | component missing stroke(s) | 0.00 | 23.53 | 56.00 |
| 8h | component has additional stroke(s) | 0.00 | 0.00 | 4.00 |
| 8i | non-component (several incorrect strokes) | 0.00 | 23.53 | 8.00 |
| 8j | missing component | 20.00 | 5.88 | 4.00 |

There are several notable changes for Group 1. Both error type 8a (stroke too long) and error type 8b (stroke too short) showed a large decrease from 30% to 4% in both cases from Week 4 to Week 8. Error type 8e (use of one incorrect component) showed an overall increase from Week 4 (10%) to Week 12 (20%). The largest change was in error type 8g (component missing stroke), which increased from 0% in Week 4 to 56% in Week 12. There was also a marked decrease in error type 8j (missing component) from Week 4 (20.00%) to Week 12 (4.00%). To summarize the findings, Group 1 shows a considerable reduction in errors relating to stroke length (categories 8a and 8b), a large increase in component missing stroke errors (8g) and a reduction in missing component errors (8j).

## 7.4 Student feedback survey

Participants completed an online feedback survey in which they were asked to give their opinions on the Intra-Character Awareness Exercises they used during the semester. The content of the responses was organized thematically into categories relating to (a) workload, (b) enjoyment, and (c) perceived effectiveness, as defined in Chapter 6. Responses were also labelled as 'positive' or 'negative' according to whether the feedback was deemed to be favourable or critical. Direct quotations from respondents are included wherever it was deemed that a key observation was made relating to that exercise.

### 7.4.1 Comparison of groups

As described in Chapter 6, an independent samples t-test was performed for each survey section relating to an exercise so that any statistical differences in responses across groups would be clear. The t-tests showed that there were no statistically significant differences ($p \leq 0.05$) in the mean responses between Group 0 and Group 1 for any of the three exercises. See Appendix M for a full breakdown of the three tests. This indicates that, although there are variations in how individual respondents rated a particular exercise, the overall evaluations are generally consistent across groups. For that reason, responses from both groups relating to the exercises are combined in the findings and discussion.

### 7.4.2 Key findings on student feedback survey

#### 7.4.2.1 Overall

Figure 45 below shows an overall representation of how the participants answered for each type of ICA exercise (self-assessed writing, kanji decomposition, kanji glyphs), based on the responses from Sections 1-3 of the survey. These sections used a low-to-high scale based on the 7-point Likert scale. As outlined in Section 6.6.3, questions from Sections 1-3 were used to gather data on the workload (blue bar), enjoyment (orange bar), and perceived effectiveness (green bar) of ICA exercises, as reported by respondents.

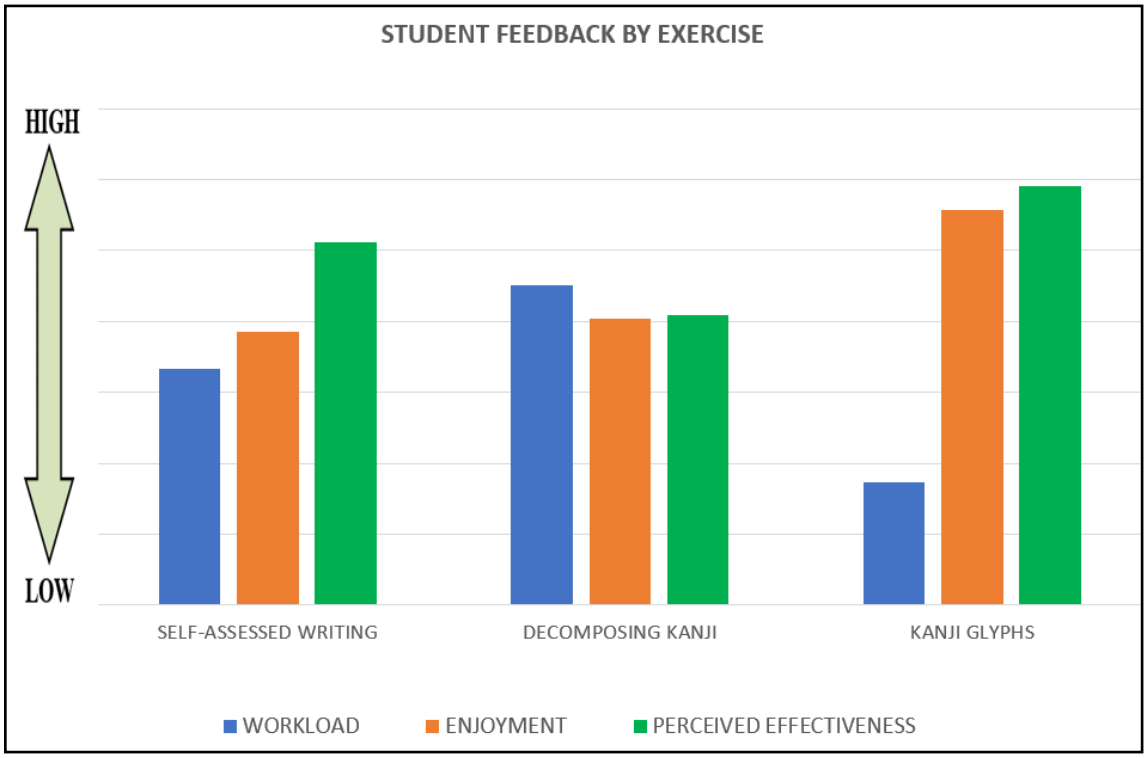



*Figure 45: Student feedback by exercise category*

#### 7.4.2.2 Self-assessed kanji writing exercises

Figure 46 shows the relative evaluations from respondents in Section 4 of the survey, with numbers of coded references from the thematic analysis relating to each of the categories and whether the response was positive or negative.

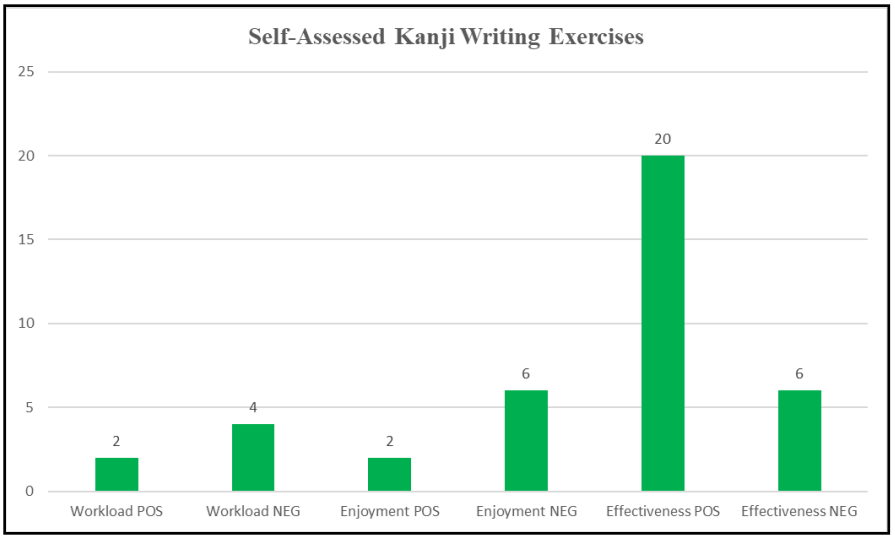



*Figure 46: Student feedback on self-assessed writing exercises*

For the category ‘Workload’, 2 of the coded references contained a positive comment relating to the workload of these exercises, while 4 of the references contained a negative comment. For the category ‘Enjoyment’, 2 of the references contained a positive comment, while 6 contained a

negative comment. For the category 'Effectiveness', 20 of the references contained a positive comment, while 6 contained a negative comment. See below for sample excerpts of some comments contained in the responses.

| Self-Assessed Writing | Quotation from respondent |
|---|---|
| (Positive) | "a very efficient way to study and memorise kanji" |
| (Positive) | "They were useful for practising writing Kanji and getting used to stroke orders". |
| (Positive) | "It's a good idea and definitely helped cement the writing order and radicals of kanji in my brain". |
| (Negative) | "I don't see how it contributed to learning the kanji". |
| (Negative) | "It's hard to evaluate every time you write a kanji, particularly when it's the same one over and over again". |
| (Negative) | "less tedious if exercise (a) was to write 20 kanji 10 times (7 from scratch) as opposed to 16 kanji 20 times (17 from scratch)". |

#### 7.4.2.3 Kanji decomposition exercises

Figure 47 shows the relative evaluations from respondents in Section 4 of the survey, with numbers of coded references relating to each of the categories and whether the response was positive or negative.

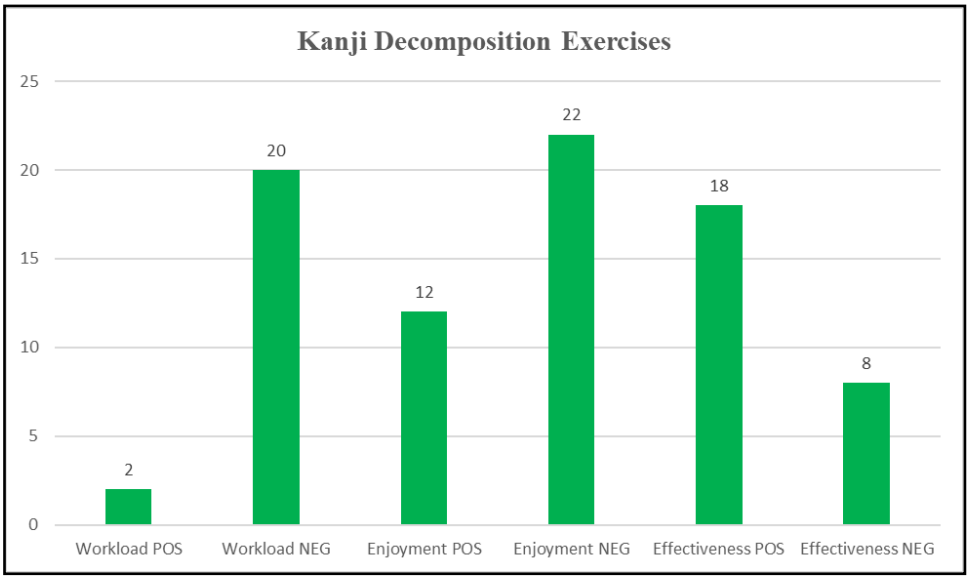



*Figure 47: Student feedback on kanji decomposition exercises*

For the category ‘Workload’, 2 of the coded references contained a positive comment, while 20 of the references contained a negative comment. For the category ‘Enjoyment’, 12 of the references contained a positive comment, while 22 contained a negative comment. For the category ‘Effectiveness’, 18 of the references contained a positive comment, while 8 contained a negative comment. See below for sample excerpts of some comments contained in the responses.

| **Kanji Decomposition** | **Quotation from respondent** |
|---|---|
| (Positive) | “Was good in better recognising kanjis by defining characteristics”. |
| (Positive) | “Helped to me realize you can find meaning to a Kanji Character by breaking it down into its radicals”. |
| (Positive) | “It was a really good way to remember the makeup of some of the more difficult kanji”. |
| (Negative) | “Taking the Kanji apart into smaller parts was quite confusing”. |
| (Negative) | “It wasn't always clear to which degree we should decompose the character”. |
| (Negative) | “It was difficult at times to find kanji containing certain radicals”. |

#### 7.4.2.4 Kanji glyph exercises

Figure 48 shows the relative evaluations from respondents in Section 4 of the survey, with numbers of coded references relating to each of the categories and whether the response was positive or negative.

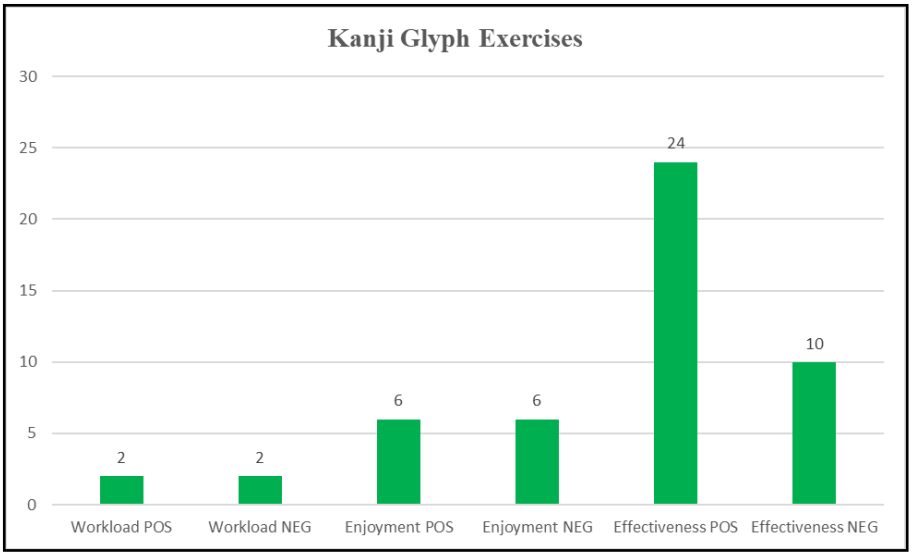



*Figure 48: Student feedback on kanji glyph exercises*

For the category ‘Workload’, 2 of the coded references contained a positive comment and 2 contained a negative comment. For the category ‘Enjoyment’, 6 of the references contained a positive comment, while 6 contained a negative comment. For the category ‘Effectiveness’, 24 of the references contained a positive comment, while 10 contained a negative comment. See below for sample excerpts of some comments contained in the responses.

| **Kanji Glyphs** | **Quotation from respondent** |
|---|---|
| (Positive) | “but overall it honestly did make me remember them a lot easier than if I were to make myself study them on my own without these sheets”. |
| (Positive) | “this was the most beneficial of all three sections”. |
| (Positive) | “It made you analyse the kanji in a way that wasn't time-consuming at all”. |
| (Negative) | “it seemed kind of pointless to do these exercises after having extensively written each kanji in the self-assessed writing bit”. |
| (Negative) | “the odds of making a mistake in the first column were very low, so it was just like re-doing the self-assessed writing over again”. |
| (Negative) | “going back and forth between the worksheets and apps or my laptop was frustrating”. |

The overall findings and the responses relating to each individual exercise type are discussed below in Chapter 8.

# 8 PHASE 2: Discussion

## 8.1 Introduction

This chapter presents a discussion of the findings from PHASE 2 and how those findings address the primary and secondary research questions. Section 8.2 discusses how the findings answer Research Question 1, using eye-tracking fixation times, the visualization of data, and instances of kanji writing errors to identify and explain observed changes pre-semester and post-semester. Section 8.3 addresses Research Question 1b by focusing on how the findings from the kanji writing error analysis, in conjunction with eye-tracking data, identified specific patterns that emerged over the 12-week semester, particularly in the Non-Kanji type errors, revealing some key differences between the two groups. Section 8.4 answers Research Question 1c by discussing how the findings from the student feedback survey identified some key issues that could impact the successful implementation of component analysis in teaching materials. Finally, Section 8.5 summarises the main conclusions from all the stages of PHASE 2. As acknowledged in Chapter 9, the limited sample size involved in this study was an important consideration when interpreting the findings and conclusions in this chapter.

## 8.2 Discussion of Research Question 1

This section discusses the primary research question RQ1 (*To what extent does using a component analysis kanji learning strategy facilitate learners' awareness of the compositional features of kanji characters?*). The discussion centres on tracking and understanding the changes observed in both groups and the possible causal factors involved by referring to the findings on eye-tracking and linking them to relevant findings in the kanji writing error analysis. It is argued that the findings indicate, albeit in a limited manner, that Group 0 have begun to develop an ability to decompose kanji characters efficiently through an increased awareness of compositional features. Group 1, on the other hand, show some evidence of decomposition skills but also appear to have

difficulty with component-level processing, suggesting that they may be struggling to develop compositional awareness. The groups are discussed separately below since there were clear differences between them in the findings.

### 8.2.1 Changes in Group 0

The clearest changes in Group 0 were the reduction in '*hen*' and increase in '*tsukuri*' fixation times. Findings from both the Gaze Plot data and Heat Map data offered confirmation of this, showing a general decrease in the number and magnitude of individual fixations within the '*hen*' AOI and a general increase in fixations in '*tsukuri*'. This can be interpreted as evidence that the students are processing the '*hen*' component more quickly and spending more time on unfamiliar components like '*tsukuri'*. In conjunction with this, the findings offered detailed insights into how the readings can be interpreted in more detail. The most likely explanation, though indicatively only, appears to be that Group 0 had begun to develop rudimentary but efficient component recognition responses through a process of noticing specific orthographic details in the characters.

One change that is evidence of the above is that Group 0 showed a 'diffuse' gaze in the Gaze Plot POST readings. Figures 35-37 (reproduced below for reference) showed examples of this effect, which is characterized by the distribution of fixation points within an individual AOI appearing to change from a general concentration on a central axis to a somewhat wider spread of fixation points. Whereas the PRE images show that the fixation points have a general tendency to line up along a component's axis, the wider spread of points in the POST images suggests that the reader may be noticing more details in the periphery of the character. They may be more attuned to picking out individual strokes or points by literally moving the gaze directly to that area and then moving back. Figure 36, which shows the kanji 待, is an example of this. In the PRE image, the fixation points are generally focused on a central axis in each component, whereas in the POST readings, there is an obvious increase in fixations on the single diagonal stroke in the lower part of the right-positioned component. The pattern of distribution also appears to trace individual strokes more than in the PRE readings. This is also apparent in Figure 37, which shows the kanji 勉. Here, once again, there is a concentration of fixations on a central axis in both components in the PRE

readings but a wider spread in the POST readings. For example, there were no fixations at all on the leftmost or lowermost strokes in the PRE image, but several fixations on those strokes in the POST image, as indicated by the white arrows in Figure 37.

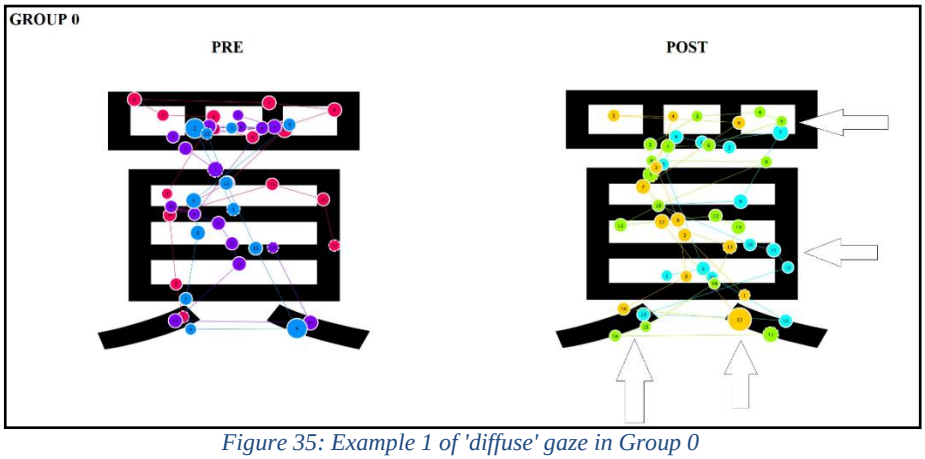



*Figure 35: Example 1 of 'diffuse' gaze in Group 0*

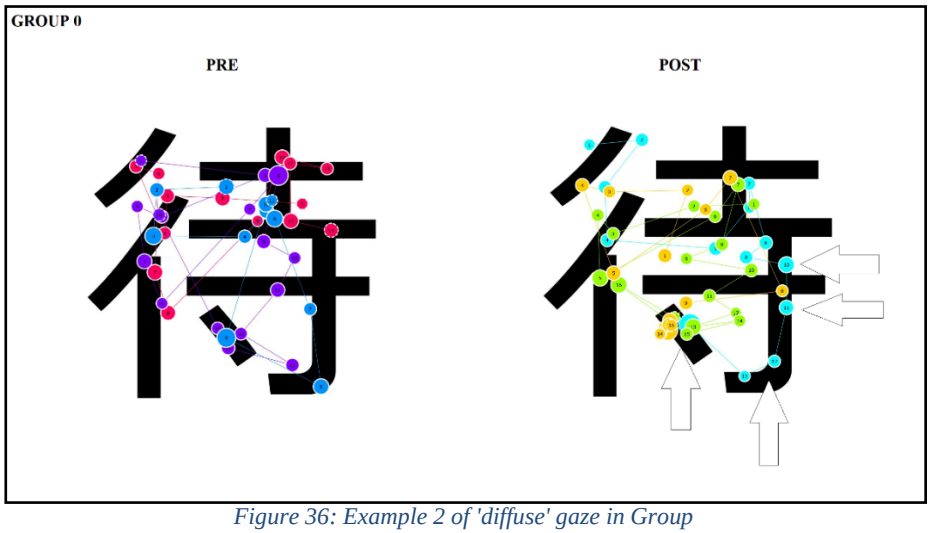
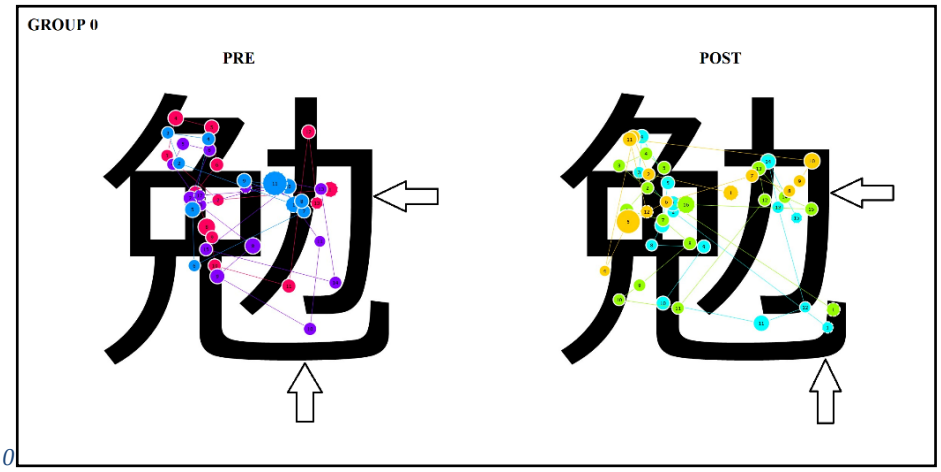



*Figure 36: Example 2 of 'diffuse' gaze in Group*




*0*

*Figure 37: Example 3 of 'diffuse' gaze in Group 0*

Group 0 also showed a general increase in the magnitude of individual fixations at specific points within characters. These are represented graphically as dynamic changes in the size of a plotted circle, with shorter fixations displayed as smaller circles and longer fixations displayed as larger circles. Figure 38 in Chapter 7 shows several examples of this pattern of larger circles, particularly on individual strokes or points of detail within a character. The kanji characters 夜, 寺, and 待 were given as representative examples of instances where specific points within a component appeared to produce longer fixations (larger circles) than previously. In conjunction with the 'diffuse' distribution pattern discussed above, this phenomenon suggests that Group 0 developed a somewhat more sensitive capacity to perceive orthographic details within the characters than they previously had. Not only was the distribution of fixations broader and more diffuse, but the magnitude of fixations on relevant points of detail in the AOI was also larger.

Related to the above, another effect that was observed in Group 0 was a focus on individual lines, which appears as a 'tracing' effect. Figure 42 showed examples of characters in which this effect was seen. The pattern is especially noticeable in some characters, with the findings showing that the gaze is tracing the length of individual strokes or has focused on specific small 'dots' within the character. This effect is further evidence that Group 0 are beginning to develop the capacity to notice detailed orthographic elements of the components in the kanji. While bearing in mind the limited sample size in this study, these findings suggest that Group 0 may have begun to acquire a degree of intra-character awareness that allowed them to perceive detailed compositional information inside components. As mentioned in Chapter 9 below, future research with larger sample sizes could serve to clarify these observations further.

In attempting to understand the changes in further detail, possible causal factors must be considered. As discussed in Chapter 3, studies on eye-tracking have provided evidence of a connection between eye movements (saccades, micro-saccades, etc.) and cognitive load. Applying that argument to the findings of this study, it is reasonable to claim that, in the POST readings,

Group 0 are showing evidence of less cognitive load for the '*hen*' AOI and more cognitive load for the '*tsukuri*' AOI. In other words, processing the '*hen*' component has become less demanding over time, while processing the '*tsukuri*' component has become more demanding. The '*hen*' AOI differs mainly from the '*tsukuri*' AOI in both positioning (left), relative frequency of occurrence (more frequent), but also in the type of information that is generally encoded in the component. This creates three possible variables for consideration as potential contributory factors to the observed changes: (a) the positioning of the components, (b) the frequency of the components, or (c) that the type of information encoded in the components. Clearly, it is also possible that a convergence of these factors is responsible, with each or all being a contributory factor.

Taking these variables in order, component positioning should be considered first. It is unlikely that the simple positioning of a component can plausibly account for the degree of change seen in '*hen*' for Group 0 because similar changes were not observed in other radical categories. If the change was produced mainly by some type of visual-spatial effect manifested in positioning, other similar types of changes would be expected in upper-positioned or lower-positioned components. Such changes were not seen in the data. For the increase in '*tsukuri'*, component positioning is more plausible as a causal factor. For example, one of the characters used was 時 ('time'). This is classified as a phonetic character because one character pronunciation is derived from the right-positioned '*tsukuri*' component. However, the same component exists itself as a fully formed kanji 寺 ('temple'). In other words, the component contains relevant semantic and phonological information. To successfully process it, the brain must first recognize it and then make a decision related to its content. For compound-ideographic characters, the semantic information in the '*tsukuri*' component may be most relevant. For phonetic characters, the phonological content may be more relevant. Thus, the process of interpreting the component's information is dependent on its position in some characters.

The second variable, that component frequency may have produced or contributed to the changes, is somewhat plausible for both '*hen*' and '*tsukuri'*. A salient feature of kanji radicals is that a

number of them frequently recur in many characters. As noted by Tamaoka et al. (2017), "the top 20 radicals encompass 1132 kanji (or 53.0 %) in the list, suggesting that a small number of radicals are frequently used to construct the majority of kanji" (2017, p. 699). This makes it likely that during any study involving the use of kanji, some radicals will occur more frequently than others. For this study, it is likely that students were exposed to some radicals more than others during the 12-week period, allowing them to develop a familiarity with certain radicals. However, if this was the primary contributory factor in the observed changes, it would be expected that other familiar radicals such as '*kanmuri*' or '*ashi*' would also show a commensurate effect. However, such an effect was not found in this study, suggesting that it is unlikely that radical frequency was a primary causal factor. On the other hand, '*tsukuri*' components occur far less frequently, meaning that the participants likely had much less familiarity with them. The increase in '*tsukuri'* fixation times could be interpreted as a function of this, with students needing more time to process components that were less familiar due to their relative infrequency.

The third possible contributory factor was that the type of information contained in the component (i.e. semantic or phonological) could be responsible for producing or contributing to the changes. In general, '*hen*' components are dominant radicals that contain semantic information and contribute to the overall meaning of a kanji character, whereas '*tsukuri*' components are generally a feature of compound ideographic or phonetic kanji. If the changes are to be attributed to this phenomenon, it would mean that participants are processing semantic components more quickly and using more time to process phonological components. The kanji writing error analysis supports this possibility. Group 0 shows a slight increase in Semantic-type writing errors (Type 3) over the semester. This is an indication that the students were using a semantic processing route more than before, since an increased use of processing route results in an increase in errors, as seen in Hatta et al. (1998) and others. At the same time, the writing error analysis shows no significant change for Phonological (Type 1) errors, a decrease in Orthographic errors and many Non-Kanji type errors. This suggests that the students were processing semantic components somewhat more efficiently and had developed some orthographic awareness but were still struggling with phonetic components. This bolsters the conclusion that the type of information contained in the component

played a strong causal role in the observed changes because this would only have been possible if they had begun to process characters on the component level, differentiating between semantic and phonetic components. Therefore, taking into account both eye-tracking and writing error data, it appears that the observed changes for Group 0 are most likely attributable to an increased efficiency in processing semantic components and an ongoing difficulty in processing components that contain both semantic and phonological information. This is significant because the finding would only be possible if the students had developed an ability to distinguish and process individual components, suggesting that they had begun to develop kanji decomposition skills that are predicated on an increased awareness of compositional features. Component positioning and frequency may also contribute to some extent.

### 8.2.2 Changes in Group 1

Although the Group 1 eye-tracking data did not show changes of the same magnitude observed in Group 0, there were still differences that must be considered in conjunction with the other data sets, as well as comparing the findings between groups. The most prominent patterns observed in the findings were the increases in '*hen*' and '*tsukuri*' fixation times, a 'top-down' effect, and a 'centralized gaze' effect. As argued below, these are taken as evidence that Group 1 had difficulty adapting to a component analysis strategy, even showing less efficient kanji decomposition responses than Group 0 at times, despite Group 1 having previous knowledge of kanji.

Group 1 shows an increase in both '*hen*' and '*tsukuri*' AOI fixation times. The increase in '*hen*' is unexpected because it appears to contradict the reasoning outlined above for the Group 0 changes. Applying the same logic, the expected finding would be that '*hen*' radicals would be processed more quickly than before due to a combination of frequency/familiarity and increased efficiency in processing semantic information. The findings from the kanji writing errors analysis show only a minor change in error rates of Semantic (Type 3) errors for Group 1, suggesting that the use of that processing route has not altered significantly. Therefore, it is difficult to attribute this increase to the component content. Since Group 1 already had some prior experience with kanji, it can also be

assumed that they were already somewhat familiar with many of the '*hen*' components that appeared in the beginner-level module being taught, making it unlikely that component frequency was a dominant factor. The positioning of the component may, therefore, be able to explain the increase to some extent. If Group 1 had not used a kanji learning strategy that emphasized components in terms of composition, position, and content before, using ICA Exercises may have had the effect of increasing their awareness of the function of different types of components. If they had not viewed '*hen*' as a carrier of semantic information before, the exercises might have triggered a process of re-examination when reading kanji. This adoption of a new strategy would likely cause some problems in processing, particularly if they are not accustomed to analysing individual components. Whereas before they may have simply looked at a previously learned character and simply read it on a single-character or compound word basis, the new process of trying to view characters as a collection of components may result in a checking process whereby they feel that they know the character but are making sure by paying more attention to specific areas. Furthermore, whereas for Group 0, radical positioning was considered unlikely as a primary causal factor because no other positioning effects were observed, for Group 1, there were other positioning effects, such as the 'top-down' effect. The 'top-down' effect (Section 7.2, Figure 43) is characterized by a concentration of fixations that appears to shift from the uppermost '*kanmuri*' AOI downwards toward the central AOI. This combination suggests that for Group 1, component positioning may have been relevant. It may be an indication that they experienced a re-adjustment phase whereby the learning method triggered an increase in cognitive load that was related to the positioning of radical components. For the '*tsukuri*' component, as with Group 0, the most plausible explanation of the increase in fixation times is a convergence of the factors of positioning, frequency, and component content.

Figure 44 (Section 7.2), reproduced below for reference, presented several examples of Group 1 data that appear to show a 'centralized' gaze in both the PRE and POST measurements.

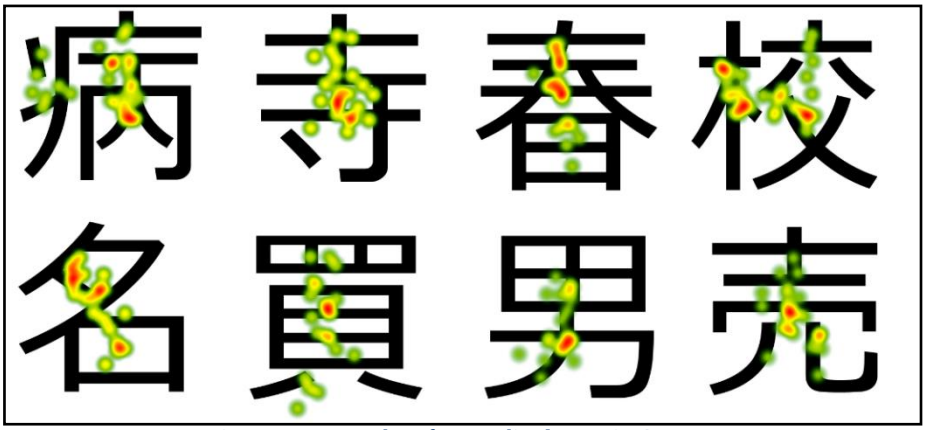


*Figure 44: Examples of 'centralized gaze' in Group 1*

This effect stands in contrast to the wider and more diffuse spread of fixations seen in Group 0. The fact that the 'centralized' gaze is apparent both before and after the semester might be an indication that the ICA exercises may not have had the intended effect of increasing specific intra-character awareness or attention to detailed orthographic aspects in the characters. Unless Group 1 somehow has the ability to apprehend specific details of the character with their peripheral vision, this finding seems to suggest that Group 1 has not shown a notable increase in component-level awareness. While the longer mean and sum fixation times on the '*tsukuri*' AOI suggest that they are trying to process the unfamiliar components, the gaze often seems to remain uniformly concentrated on a central axis, especially in kanji that have left and right components. Furthermore, kanji writing error data for Group 1 shows a progressive and accelerating increase in Non-Kanji (Type 8) errors, suggesting that the group struggled to successfully store in their memory or retrieve from their memory new kanji components over the course of the semester. The failure to effectively store or retrieve new components, considered in combination with evidence of a 'centralized' gaze in PRE and POST readings, appears to show that Group 1 had limited success developing awareness of compositional features in the characters. While this may have implications about the learning strategy itself, it is important to understand that this study was twelve weeks long. This is a relatively short period of time relative to the overall length of the learning process. Group 1 may have needed more time to adapt to the strategy, having already used different types of strategies for approximately one to two years. They may have found the exercises confusing, or it may have been difficult to disengage an alternate processing mechanism that had already been established. Therefore, this finding must not be overstated. It may be an indication that component analysis is something that should be introduced to learners early in the learning process so as not to confound

them by learning one method and then trying to reverse or integrate other methods. On the other hand, it may also mean that learners who already have some experience with kanji require more than twelve weeks to successfully adapt to a strategy to which they are simply unaccustomed. Further research, with larger sample sizes and conducted over longer periods of time, could help clarify whether the apparent difficulty experienced by Group 1 was a short-term phenomenon.

### 8.2.3 Other findings

Figure 39 in Section 7.2 showed an example in which both groups show evidence of a 'narrowing effect' in enclosed or semi-enclosed kanji characters. The term 'narrowing' is used here to describe a distribution of fixation points that generally changed from having several points of focus on the outermost strokes to having few points of focus on those strokes. The fixations narrow towards the internal or central component. This was evident in characters such as 国 and 昼. Since the source materials do not contain a large number of these kanji types, it is difficult to draw conclusions about this effect in isolation. One plausible explanation is that for enclosed or semi-enclosed characters, the external strokes of the enclosure are being processed quickly with peripheral vision, leaving the bulk of the processing to the component inside the enclosure. It is not clear whether positioning or frequency may affect this. The effect is interesting in terms of its possible implications for kanji learning, but there is insufficient data in this study to offer any serious conclusions as to its probable cause or consequences. Further research that focuses specifically on enclosed characters is recommended, enabling a specific examination of the role of peripheral vision in kanji processing.

One final point is worthy of mention. By comparing Group 0 POST with Group 1 PRE, it is possible to estimate what a typical processing trajectory might be in the case where component analysis is not used. Participants in Group 1 had approximately one to two years of prior kanji learning experience, with no explicit use of component analysis. One of the challenges in this study is the question of how to ascertain the degree of influence of Intra-Character exercises relative to

the possible influence of time and LX exposure. Attributing the observed changes to component analysis is an underlying assumption of this approach. Since Group 1 did not use component analysis before, their PRE readings can be considered to be a typical response for a group of learners with some kanji experience. If Group 0 had not used component analysis, it is reasonable to assume that their POST readings would then resemble the Group 1 PRE readings. For example, it would be logical to expect Group 0 to develop a 'centralized gaze', as seen in Group 1. Since that did not happen, it is reasonable to suggest that the changes observed in Group 0 can be attributed to the influence of ICA Exercises and not the influence of general exposure to the target language.

## 8.3 Discussion of Research Question 1b

This section discusses how the findings address Research Question 1b (*What are the factors that influence the changes observed in kanji learners?*), aiming to identify, understand and explain the qualitative processes involved in the changes observed in the two groups over the semester. The discussion centres on the findings from the kanji writing error analysis and links this with the eye-tracking findings where relevant. It is argued that the writing error analysis, particularly that of the Non-Kanji errors, reveals that Group 0 shows some evidence of increased compositional awareness because of a reduction in component-level errors and an apparent sensitivity to orthographic details. A key finding for Group 1 was a large increase in Non-Kanji errors as the semester progressed, the nature of which suggests that they had particular difficulty noticing compositional details in newly-learned kanji.

### 8.3.1 Overall errors

The key findings for the overall errors were a high Non-Kanji error rate in both groups, a reduction in Orthographic errors in both groups, and a slight increase in Semantic errors (larger in Group 0). Taking the high Non-Kanji error rates first, this supports the findings from previous studies that used $L1^{alpha}$ participants and can be seen as a reflection of how the students still have only a

rudimentary basis on which to attempt to reproduce kanji from memory. One of the key differences between L1 and LX readers, as discussed in Chapter 2, was that L1 readers are more adept at extracting and using phonological information while processing kanji. This is a key point because it is clear that a kanji can only be reproduced correctly if the components have first been effectively encoded to memory, allowing successful retrieval. The high Non-Kanji errors appear in tandem with very low or non-existent Phonological (Type 1) errors in both groups. While sample size is an acknowledged limitation in this study, this finding can be considered as evidence that neither group has yet managed to achieve stable and efficient processing of phonological information. At lower levels of proficiency, this is to be expected. However, variations in the nature of these errors revealed differences in how the groups were appearing to process the characters, as seen in Section 8.3.2.

An important finding from the overall Non-Kanji (Type 8) errors is that Group 1 shows a dramatic increase from 43% to 73%. As pointed out in Hatta et al. (2002), the cause of Non-Kanji errors is that learners "have not yet established the correct orthographic representations of kanji and their elements" (2002, p. 164). That conclusion is uncontroversial since kanji consists of thousands of characters composed of even more components. Learners need time to establish accurate representations of kanji in their memory before they can successfully reproduce them in writing. However, such a large increase in NK errors by Group 1 was unexpected, given that they had some prior experience learning kanji. The large increase suggests that Group 1 experienced serious difficulties dealing with the increased demand of 15-20 new kanji being introduced each week. It is possible that in the early weeks of the module, very basic kanji, which they already knew well, were being taught. As the course progressed, new and unfamiliar characters were introduced, resulting in problems committing these to memory. The finding that Group 1 ended up with a comparable NK error rate to Group 0 after only one semester is unexpected because their experience and familiarity with kanji should have manifested in an ability to produce more accurate written kanji than the ab-initio beginners in Group 0. Therefore, while there is some evidence that Group 1 had success in developing compositional awareness, as discussed below, this finding alone

indicates that whatever success they had is undermined by the apparent problems they showed in this category of errors. It should also be noted that final NK error rates for Group 0 (79%) and Group 1 (73%) are comparable to findings by Hatta et al. (2002), who reported that LX learners had an NK error rate of 76% (2002, p. 161). The specific characteristics of the Non-Kanji errors for both groups are discussed in more detail in Section 8.3.2 below.

The decrease in orthographic errors seen in both groups suggests that students had some success in developing compositional awareness. Previous studies have found that low rates of orthographic errors are correlated with increased writing proficiency, with $L1^{morph}$ adults showing significantly lower rates than both $L1^{morph}$ children and $L1^{alpha}$ learners, as discussed in Section 3.3. Thus, orthographic error rates are a useful way of understanding to what degree a learner has managed to store representations of kanji components in their long-term memory successfully. In early stages of learning, for both $L1^{morph}$ children and $L1^{alpha}$ learners, these error rates tend to be quite high since the learner has not yet had enough time to establish accurate representations in their memory. The expectation, then, is that as learners progress in their study of kanji, they should show a reduction in orthographic errors, assuming that they are using an effective learning strategy that facilitates compositional awareness. In this study, both groups showed a reduction in orthographic (Type 2) errors over the 12-week period, with Group 1 showing a larger reduction than Group 0. This finding, while based on a small sample size, suggests that participants had some success in reproducing kanji characters with more accuracy than before. This is encouraging from the standpoint of using component analysis in teaching kanji since it provides some evidence that learners who are instructed to learn kanji this way can show increased awareness of compositional features in kanji and the ability to reproduce them more accurately than before. Furthermore, Group 0 finished Week 12 with a slightly lower overall rate of orthographic errors than Group 1. This is also promising from a pedagogical view, given that Group 0 were ab-initio beginners and in 12 weeks had managed to achieve lower rates of orthographic errors than the lower-intermediate learners of Group 1.

The increase in semantic errors seen in both groups, while small, is worthy of brief discussion, especially in the context of the eye-tracking findings for both groups. Group 0 shows a reduction in '*hen*' fixation times accompanied by an increase in semantic kanji writing errors. These two types of data support the hypothesis that Group 0 began to use semantic processing more effectively as time progressed. Group 1, on the other hand, showed a slight increase in '*hen*' fixation times and a slight increase in semantic writing errors. After the 12-week semester, both groups had an equivalent semantic error rate, while Group 0 had a lower mean fixation time on the '*hen*' component than Group 1. This seems to indicate that, while both groups are able to use a semantic processing route when reading kanji, Group 0 appear to be doing this somewhat more efficiently than Group 1. Error rates are equivalent, but Group 1 take longer to process '*hen*'. This could be an indication that Group 1 are having difficulty adapting to component analysis, which is an unfamiliar method to them. Adjusting their style of learning and practising kanji may have caused a degree of uncertainty in reading the characters as they attempt to incorporate the new method into their processing mechanism. What this may also suggest is that component analysis could be a suitable strategy for beginners. If a learner has tried various methods without a specific and coherent plan, it may be difficult to switch to component analysis, having already relied on other methods. A beginner, on the other hand, could develop the skill of perceiving kanji as components and progress from that starting point. Put simply, the findings suggest that it might be easier for a learner to use component analysis from the outset rather than switching to it after a few years of study. Of course, the problem of mapping the components and kanji onto an incomplete lexicon exists. Further research could attempt to investigate the role of memory and lexical knowledge early in the kanji learning process.

### 8.3.2 Non-Kanji errors

The refined framework of Non-Kanji (Type 8) errors (ten categories relating to compositional details) was used with the aim of trying to understand the qualitative nature of the writing errors in more detail. To provide an illustrative example from the source materials, the character 売 (buy) was a target kanji for the participants. Several students made a written attempt that was very close

to being correct but was still imprecise in some small detail. Figure 49 below shows a recreation of an error made by several students.


*Figure 49: Example of Non-Kanji (Type 8) writing error*

Within the overall framework, this would be marked as an error under the Non-Kanji category since the final result does not exist as a character in itself. However, it is also true that simply marking it as incorrect does not reveal how close the student came to making a correct attempt. It is apparent from Figure 49 above that it was a somewhat minor error of stroke length within the upper component, marked in red. The lower component was correct, and the compositional balance was generally accurate. Errors such as these made it clear that an in-depth discussion of the data required a more sensitive measurement for categorising the writing errors. As explained in Chapter 6, ten kinds of Non-Kanji errors were identified and labelled.

#### 8.3.2.1 Errors relating to stroke length and direction

One noticeable aspect of the data was the changes in Group 0 relating to stroke length and direction. There was a reduction in 8a (stroke too long), an increase in 8b (stroke too short), and an increase in 8c (wrong stroke direction). These errors appear to be related in that the mistake is made within a single stroke rather than a full component, for example. The length or orientation of an individual stroke was the source of the error for all these categories. These three error types account for a total of 42% of all errors by Week 12 for Group 0. It is reasonable to argue that errors of this type are not as serious as other types of error, such as errors that involve missing strokes or more egregious cases involving the complete absence of a component. Both are errors, but with errors of orientation or length, at least a reasonable attempt was made, and the overall result is probably much closer to the correct version than an attempt that contains missing strokes. When a learner attempts to write a kanji and makes an error that relates only to stroke length or orientation,

it may be that they already have a reasonably well-formed representation of the components stored in their memory. If they did not, the expectation would be that the components would have missing or additional strokes or even be absent. The errors of length and angle suggest that the problem is more to do with incomplete spatial awareness rather than incomplete representations of the components themselves. It is as if a learner knows which strokes should be used to produce a component but fails to adequately retrieve information about the specific length or angle of those strokes. The finding that Group 0 made many of these errors while Group 1 made more serious errors suggests that Group 0 had a somewhat more developed sensitivity to compositional features.

#### 8.3.2.2 Errors relating to components

At the same time, Group 0 shows a reduction in 8g (component missing stroke) from 19% to 10% of all NK errors by Week 12. Error type 8h (component has additional stroke) remained relatively constant. This is also a potentially significant finding. It must be remembered that this was a group of ab-initio beginners who were learning 15-20 new kanji characters each week of the semester. It could be expected that errors of missing strokes or additional strokes might be relatively high, but Group 0 appeared to cope well with learning new material. The relatively low error rates of missing or additional strokes suggest that they managed to maintain reasonably well-formed representations of individual components in their memory and were often able to reproduce them correctly. It suggests that they showed some signs of perceiving kanji as collections of components rather than as a jumble of strokes. This is a key point to emphasize. A preponderance of extra strokes or missing strokes would indicate that the learners were not forming accurate representations of whole components in their memory but instead seeing a whole character as a collection of strokes. In that case, the expectation would be for the learner to make errors mainly related to forgetting a stroke or placing too many strokes, or placing them in the wrong part of the character. However, Group 0 seem to have relatively intact representations of components, as evidenced by the lower numbers of missing/extra stroke errors, combined with higher rates of length/orientation errors.

#### 8.3.2.3 Group 0 increase in non-component errors

Another notable finding for Group 0 was error type 8i (non-component, i.e. producing a component that does not exist), which increased from 5% to 12%, and error type 8j (missing component, i.e.

producing a character that lacks an entire component), which remained relatively unchanged at approximately 19%. These two error types are examples that could signify a failure to encode representations of components into long-term memory properly. When a learner arranges the strokes in a completely incorrect way, or they simply cannot even make an attempt, it is evident that either they have failed to create an adequate memory encoding or that they cannot retrieve it. Together, these error types accounted for approximately 25% of all errors in Week 4 and 30% of all errors by Week 12. Given that the group had learned an additional 120 kanji in the intervening period, it could be expected that the error rate would increase by more than it did. On the whole, the findings suggest that Group 0 had reasonable success with component analysis, as evidenced by a concentration of errors relating to stroke length/orientation and a component-level error rate that showed only a slight increase as the workload accumulated.

#### 8.3.2.4 Group 1 errors

There are several points of interest in the Group 1 findings that warrant discussion. The first is that there was an evident change in 8a (stroke too long) and 8b (stroke too short), with a large reduction from 30% in Week 4 to 4% in Week 12 for both categories. This is interesting because, as with Group 0, it seems to suggest that the group have developed a more attuned sensitivity to individual strokes. Whereas before, they were making a considerable number of errors relating to stroke length, by the end of the semester, these errors have almost been eradicated. While Group 0 shows fluctuations in these error types, Group 1 shows signs that the ICA exercises had the effect of focussing their attention on the details of single strokes. Error rates relating to stroke direction were absent in all Group 1 samples. This seems to be consistent with the overall pattern of writing errors for Group 1, in that Orthographic errors (Type 2) decreased by about 20% over the course of the semester. The main difference between true Type 2 Orthographic errors and Non-Kanji stroke length/orientation errors is that the latter written attempt does not actually exist as a character itself. These two decreases can, therefore, be taken as evidence that Group 1 did show a degree of increased awareness of some compositional features of the kanji over the course of the semester.

On the other hand, the most striking change shown by Group 1 was the very large increase in 8g (component missing stroke), which rose from 0 in Week 4 to 56% in Week 12. A related change of note is 8e (use of one incorrect component), which doubled from 10% to 20% by the end of the semester. A further 16% of errors relate to additional strokes, missing components or components that had several incorrect strokes. Thus, the large increase in written attempts involving missing or additional strokes (rather than stroke length or orientation) is an indication that Group 1 struggled to form or retrieve accurate representations of kanji components in their long-term memory. While the reduction in orthographic errors discussed above suggested a somewhat more developed sensitivity to compositional features, this does not appear to have translated into an overall ability to perceive the kanji as an assembly of components rather than an assembly of strokes. The overall error rate data shows that Group 1 saw a large increase in Non-Kanji type errors, and now it seems clear that the majority of these errors are a manifestation of having incomplete representations of components in the long-term memory or a failure to retrieve them. Either way, this is a fundamental qualitative difference between errors of stroke length or orientation. With errors of stroke length or orientation, it is reasonable to assume that a representation of the component is relatively intact in memory and that the error is somewhat superficial. A component that has a missing or additional stroke, on the other hand, seems like a more serious error that is characterised by a failure to perceive the kanji in terms of its constituent components.

In summary, answering Research Question 1b (*What are the factors that influence the changes observed in kanji learners?)*, the writing error analysis findings, in tandem with the eye-tracking data, indicate that Group 0 have begun to successfully develop an incipient intra-character awareness, as evidenced by stable rates of Non-Kanji errors, which showed relatively intact representations of components. Group 1 shows a tendency to perceive the kanji as a collection of strokes rather than components, as evidenced by the reduced number of errors relating to stroke length/orientation and the increased number of errors involving missing or additional strokes in components. One possible explanation of this finding is that Group 1 had difficulty switching to the new and unfamiliar method of learning kanji. They may have been so accustomed to rote writing or

associating whole characters with meaning or sound that they were unable to adapt successfully to component analysis within the 12-week period. It may be possible that given a longer time frame, they could have made a more successful transition. Group 0, on the other hand, had little to no previous experience with learning kanji. This may have been an advantage in that their learning process was well defined and had no other competing methods that may have created confusion. Chapter 9 outlines the possible pedagogical implications of these findings.

## 8.4 Discussion of Research Question 1c

The purpose of including the student feedback survey was to answer Research Question 1c (*What issues are highlighted by kanji learners who use 'component analysis' materials?*). The survey was used in order to understand the potential issues that arise when using component analysis in practical teaching materials, based directly on the subjective experiences of the students who used the materials. In this study, identifying the aspects of ICA Exercises that performed well or could have been designed better can contribute to an understanding of factors upon which the successful use of the strategy could be dependent. The exercises are discussed separately below since the responses showed some differences in how the participants evaluated them.

### 8.4.1 Self-assessed kanji writing exercises

The most noticeable trend in the findings for these exercises was the relatively high rating of perceived effectiveness in the respondents. While there were some critical responses that characterized the repetitive nature of the exercises as tedious, it seems that participants generally believed that these exercises were contributing positively towards their kanji learning goals. This finding is consistent with studies that examine the role of repetitive writing practice. For example, Mori (2014) notes that "rote learning strategies, including repeated writing, tracking, and copying, are perceived as the most effective kanji learning strategies by both L2 Japanese students and educators" (2014, p. 413). However, while students felt the exercises were beneficial, it seems they

did not find them especially engaging, with the lowest rating for ‘Enjoyment’ of all three exercises. This is an interesting finding, given that the perceived effectiveness was relatively high. It is an indication that learners may acknowledge that the learning process does not always have to be ‘fun’ in order to be effective, perhaps suggesting a tacit understanding that learning kanji is a multi-layered process that sometimes can involve engaging materials or activities, but at other times involves the simple process of sitting down with a pencil and repeatedly drilling the characters. A key aspect of rote-writing is the recruitment of motor skills (handwriting) in the learning process. Studies on both Japanese (e.g. Itaguchi et al., 2017) and Chinese (e.g. Guan, Liu, Chan, Ye, & Perfetti, 2011) provide evidence of the role that rote-writing could play in cognition. So even though the findings may show that participants did not find this exercise type engaging from an enjoyment perspective, they appear to believe in its effectiveness.

What is not clear from the findings is whether the students believed it to be effective because of the repeated writing practice itself or because it contained a self-assessed element that they found to be beneficial, or both. One of the reasons for including the self-assessed scoring system was to require the learner to repeatedly compare the model character with their own written attempt, thereby artificially increasing the number of times the learner’s gaze is targeted on the character’s components. The intended outcome of this repeated process of comparing the model to the written attempt was to increase the learner’s awareness of the compositional features of the character and repeatedly reinforce those details, thereby facilitating improved memory encoding and allowing the learner to produce accurate written kanji. Since the participants could not be aware of whether or not they were actually memorizing components more effectively, it is not possible to tell from survey responses how the perceived benefits correlate to any real observed changes. However, the point of the survey was not to specifically correlate student perceptions with actual changes in metrics but rather to understand how different aspects of the exercises were rated. From that standpoint, it remains unclear whether the inclusion of self-evaluation in the rote writing exercises was effective or not. In the open-ended responses to questions in this section, there were no responses that specifically highlighted the self-assessment element as being beneficial. On the other

hand, there were some critical responses that claimed it was difficult to evaluate a written character repeatedly.

### 8.4.2 Kanji decomposition exercises

One notable finding is that the workload for kanji decomposition exercises appeared to be substantially higher than the other exercises. Only a small number of responses contained a positive appraisal of these exercises in terms of how quickly or easily they could be completed. Furthermore, there were multiple responses that mention that it was not clear how to decompose the characters properly. This issue had been anticipated in the design of ICA Exercises, and several steps were taken to eliminate confusion on the topic, such as demonstrating decomposition techniques and introducing a variety of online resources, as described in Chapter 6. Despite these preparatory steps, the findings suggest that some students still struggled to a degree with the task of decomposing kanji. One of the complaints in the responses was that they were not sure to what extent the character should be decomposed. One error that recurred was that a radical or component would itself be decomposed into individual strokes rather than leaving it at the level of the component. For example, a target character such as 安 is intended to be decomposed into two components, the dominant radical in the upper position (宀) and the component underneath (女). However, there were several instances of the radical itself being decomposed into single strokes. Figure 50 below shows a representation of this type of 'over-decomposition'.

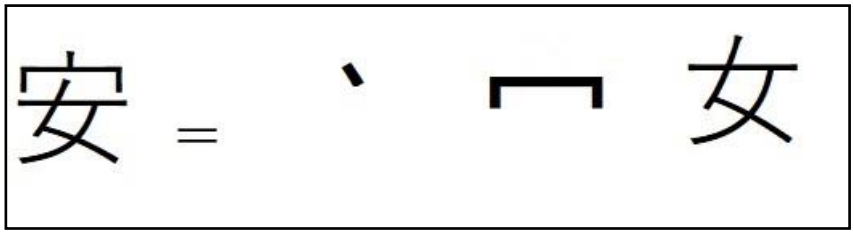



*Figure 50: Representation of 'over-decomposition'*

The problem may be caused by the learners' general inexperience with kanji, in that they do not yet have an established working knowledge of what constitutes a full component. Lacking detailed knowledge, any character or component may appear to be a collection of strokes, and it may not be clear how to identify the boundaries between components. Obviously, beginners do not possess this

knowledge, so the in-class instruction was intended to provide students with the skills to be able to search databases and find components. It was hoped that this deliberate act of searching for and finding components would provide further exposure and reinforcement to components, thereby facilitating intra-character awareness. The findings suggest that even with preparatory instruction, this task may be overly complex for learners who are still inexperienced with kanji. It may be necessary to adapt this type of exercise so that a simplified version can be implemented in a less demanding exercise. One possibility would be to use a quiz-style flashcard system that prompts the user to mentally decompose the kanji character and allows them to check their work quickly by revealing the correct answer. Resources such as Anki (Elms, 2005), Memrise (www.memrise.com), and Quizlet (https://quizlet.com) are highly customizable tools that allow the teacher to control the parameters of how the learner engages with the target items. This could be applied to kanji decomposition in a way that bypasses the potential problem of over-decomposition, allowing the learner to use the strategy in a more intuitive way. A possible downside of this approach would be that the bulk of the learning is moved on-screen, depriving the learner of the opportunity to physically write the characters and notice compositional details of the characters. Simple on-screen prompts followed by displaying pre-formatted components may be less confusing but also runs the risk of delegitimizing the strategy by removing the motor skills element from it. Striking a balance between on-paper and on-screen exercises is something teachers should strive to achieve, and this is an area that would benefit from further research. Experiments such as Umejima (2021), mentioned in Chapter 2, comparing the use of varying degrees of digital applications (as opposed to pen and paper), are helping to identify what the most effective balance of such exercise types might be.

Another difficulty that became apparent in the kanji decomposition exercises was that the participants, especially Group 0, still had a relatively small lexicon from which to make connections to other words. This could be a problematic aspect of component analysis, as pointed out by Rose (2017), who suggests that it may be less valuable for beginners since their knowledge of kanji is so limited early in the learning process (2017, p. 65). The (b) and (c) portion of the

exercises required the learner to write other kanji characters and words that contained components seen in the target kanji. This was included as a way to increase the learner's awareness of the components and to make connections in their memory between new information and previously learned information. One of the advantages that $L1^{morph}$ kanji learners have is that their lexicon is already quite developed by the time they begin learning kanji, allowing them to make direct connections between new kanji and existing items of vocabulary stored in long-term memory. While there is no way for LX learners to avoid being at such a disadvantage, attempts should be made to provide them with the opportunity to link kanji knowledge to other areas of their learning where possible. The kanji decomposition exercises aimed to do this by requiring the student to think about any other words or characters that they had previously learned and that also contained components they were practising at that moment. However, if the learner simply has not had enough time to build a substantial lexicon, there will not be a large foundation onto which to make those connections. This appears to be the case for some of the participants of this study. The submitted work shows that even when a student was able to decompose a kanji into its constituent parts successfully, they sometimes struggled to think of another kanji or word that contained those components. This happened even when there were examples of words that were on the curriculum and had already been taught. This was somewhat unexpected since it was assumed that when participants decomposed a kanji and gave their attention to the components that they would then naturally recognize a component as being part of another kanji. However, it seems that this was not easy for students. For example, one of the kanji introduced in Week 9 was 昼 ('noon'). This kanji contains the component 日. That component was present in several kanji that had already been learned during the semester, such as 間 ('interval'). Despite this, several students failed to connect these two kanji that contain a common component. The failure to make connections might be an indication that those previously learned characters have still not been stored in the memory as a collection of components. If a character's compositional makeup is not stored in this way, it would be difficult to then associate an individual component from a new character with the group of components in the previously learned character. It may also be a difficulty with retrieval, as the learner may realise that they know other characters with the component in question but are simply unable to access that information. Therefore, while the findings indicate that students sometimes

struggled to make connections between new components and previously learned kanji, it is difficult to pinpoint the exact cause of this. A likely cause is the limited size of the learner's lexicon, although it seems possible that memory and LX exposure could also play a role in this issue.

It is worth noting that 'Enjoyment' overall was moderate, suggesting that despite the difficulties some students experienced, the exercises were still engaging. There are some practical criticisms that should be addressed. For example, some of the individual responses contained criticisms of these exercises because they involved going back and forth between the printed exercise sheet and a digital application. Whether it was a website or an application on a phone, searching for the kanji character, checking its components, and then writing it on the exercise sheet seemed to be a rather laborious process. This back-and-forth between paper and screen was not conducive to maintaining concentration and keeping productivity high, according to some participants. This might be a valid criticism for kanji learners in the very early stage of the learning process. Without a firm understanding of what constitutes a component and having no real foundation of knowledge, referring to websites or applications is indispensable. On the other hand, as the learner progresses and encounters familiar components recurring in their studies, they should begin to perceive kanji characters as groups of components. When asked to decompose them, they may gradually have to rely less on external reference material. Therefore, this criticism may highlight the importance of calibrating the materials for beginners rather than it being a criticism of the strategy's effectiveness.

Finally, the comparatively low rate of perceived effectiveness relative to the other exercises was somewhat unexpected. It was expected that participants, through an increased awareness of individual components, would experience positive motivation regarding the trajectory of their kanji learning. One possible explanation for this finding is that learners did not have a clear enough sense of how understanding components could benefit their kanji learning as a whole. A learner's internal motivation for learning kanji is a key element that can carry them through the technical challenges of learning kanji. For example, Tanaka (2013) found that intrinsic motivation was a strong

predictor of kanji proficiency, explaining that “a sense of pleasure can be derived even from repetitive types of learning although this might be contingent upon the learner having a sense of progress” (Tanaka, 2013, p. 811). This is relevant because if the learner does not feel a sense of progress, it is likely that their motivation will begin to decrease. The practice of decomposing a kanji into its constituent parts is a concrete act in itself, but for the learner, it may seem like an abstract practice in the context of overall learning. Thus, it is conceivable that the kanji decomposition exercises did not provide participants with a definite enough sense of a connection between the exercise and its role in the learning process. In fact, this issue had been anticipated and was a concern during the design phase of the study. The (c) portion of the exercise, which links the component to full kanji words the learner already knows, was included to address this potential problem. The rationale was that by explicitly making a link between components and single-character or compound kanji words, the learner would recognise components more often and feel a sense that their knowledge was expanding. However, the findings indicate that for kanji decomposition, this may not have been the case. The importance of designing teaching materials that avoid unnecessarily abstract exercises is a point that must be noted.

### 8.4.3 Kanji glyph exercises

The findings from the kanji glyph exercises were the most straightforward of the three exercises to interpret. The first trend in the data was the responses showing comparatively low ‘Workload’. As one respondent puts it, “Very helpful! It made you analyse the kanji in a way that wasn't time-consuming at all. Overall very worthwhile to do”. This is a difference from the other exercises, which could sometimes be quite labour-intensive in terms of the amount of writing involved. The glyph exercises relied more on recognition aided by phonetic and semantic cues, with a smaller amount of production. In presenting the target kanji as a partially complete glyph together with the meaning and dominant readings, the goal of the exercise was to trigger a memory retrieval process. The exercise prioritized recognition based not just on orthographic details but also on semantic and phonetic factors. For example, in presenting a target kanji with one component missing and placing the meaning and readings alongside it, the learner is given an opportunity to retrieve the full

character even if it may not yet be stable in memory. Since many kanji are composed of multiple components, component analysis demands that the learner remember several individual components when learning new kanji. The purpose of glyph exercises was to reduce the memory retrieval burden by providing orthographic clues that allow the reader to fill in the blanks more quickly. This means that they could be completed quickly, assuming that the learner was able to quickly generate the full character based on the partial kanji glyph. The responses show that participants were able to complete these exercises quickly, indicating that they were not burdened by the demands of this task. The decision to make the target output of these exercises shorter was, in hindsight, justified, given that the first two exercises had a somewhat demanding workload. If the third exercise had also been a long one requiring a lot of concentration and effort, there would have been a serious risk of demotivating students. Therefore, the low workload, in combination with the findings on 'Enjoyment' and 'Perceived Effectiveness', can be considered a positive appraisal of the exercise type in the context of the whole study.

It was also apparent that participants found these exercises very enjoyable in general. 'Enjoyment' ratings were substantially higher than either of the other exercises. Taking into account the responses from the open-ended portion of the survey, it appears that many participants found the format of the exercise to be very engaging. The exercises seemed to be almost like a test of what the students had just practised in the previous exercise sections. The puzzle-like quality of the glyph exercises seems to have been a success in terms of engaging the learner. When visually presented with a partial kanji glyph, the natural response is to want to complete it. Having just completed two types of writing exercises before moving to glyph exercises, the target kanji are still fresh in the memory of the learner. The high enjoyment rating suggests that there was a sense of satisfaction in having one's knowledge tested and being able to reproduce full kanji characters successfully. Several responses suggested that the exercises could even have been made to be more challenging. However, the benefits of this exercise may have been diluted if it had been more difficult. Using a relatively simple but enjoyable exercise to trigger memory retrieval is a way to maintain motivation while providing a reinforcement of target kanji practised in previous sections.

The kanji glyph exercises also had the highest perceived benefit of all three exercise types. This is a somewhat unexpected finding given that they entailed a much lower workload than the other exercises and that learners generally view rote writing as being particularly beneficial, as seen in studies such as Mori (2014). However, the format of the glyph exercises seems to have engaged the participants in a way that they considered to be useful and effective. For example, one respondent said that "it was useful to see whether you remember a kanji correctly or not and then correct it if you remembered it wrong." Another respondent pointed specifically to perceived benefits involving components, saying that it was "helpful to remember the radicals of a kanji, but I found it confused me when it came to stroke order." How closely the perceived benefits actually correlated with measurable improvements in proficiency was not possible to monitor in this study, but the findings are encouraging in terms of considering how component analysis could be applied in the classroom and in teaching materials. For example, if the puzzle-like quality of kanji glyph exercises provides the learning process with an additional layer of engagement in the learner, it might be worthwhile to include such exercises in a range of teaching materials. On a practical level, it would be feasible to generate stock exercise templates (such as a Word document), which could be easily customised by teachers depending on the curriculum of their institution. A shared database of glyph variations for each kanji could be gradually developed by instructors, with the ability for users to drag-and-drop the glyph images directly onto a printable template and then distribute to the students. There appears to be an expanding scope of possibilities for including component analysis in kanji learning in a variety of interesting and engaging ways. The findings from this survey appear to support the inclusion of glyph-type exercises in a component analysis strategy.

### 8.4.4 Summary

The survey was used to answer Research Question 1c (*What issues are highlighted by kanji learners who use 'component analysis' materials?*). The issues highlighted in the feedback survey are a combination of practical and strategic factors and have implications for the use of component analysis in teaching materials. Responses relating to the self-assessed kanji writing exercises show that the inclusion of rote writing is justified because students appear to value it in the learning

process, even when the workload is somewhat high. While it was not clear whether the inclusion of a self-evaluation element had the intended effect, the responses generally endorse the kind of writing practice involved. Responses about the kanji decomposition exercises indicate that the successful use of component analysis in teaching materials is probably dependent on the exercises being sufficiently clear and easy for learners to understand. This would be even more important if the learners are beginners. The tasks should be tailored so that the decomposition process is streamlined or, preferably, partially automated by software in a digital application. With a limited lexicon, it seems vital to avail of as many opportunities as possible to link characters, components, and words, providing important connections between kanji knowledge that facilitates memory storage and retrieval. Establishing those links could also increase the learner's perception that the exercises are having tangible benefits on their learning, rather than being an abstract exercise that is dissociated from the other areas in their learning. The difficulty of decomposition exercises must be carefully calibrated since it can be a complex task that can risk demotivating the learner. Component analysis materials should also include engaging puzzle-like tasks that can be completed quickly and provide the learner with a sense of satisfaction. The use of glyphs positioned alongside semantic and phonetic cues appears to be a particularly suitable choice, given the strong endorsements seen in the responses. Overall, in highlighting the issues contained in RQ1c, it appears that the successful implementation of component analysis in practical teaching materials is likely to be contingent on balancing these issues to produce materials that are optimally designed in terms of workload, enjoyment, and perceived effectiveness.

## 8.5 PHASE 2 summary

Data collection and analysis in PHASE 2 was done with the aim of answering the primary Research Question RQ1 (*To what extent does using a component analysis kanji learning strategy facilitate learners' awareness of the compositional features of kanji characters?*), and the sub-questions RQ1b (*What are the factors that influence the changes observed in kanji learners?*) and RQ1c (*What issues are highlighted by kanji learners who use 'component analysis' materials?*).

Findings from eye-tracking experiments and kanji writing error analysis were used to answer RQ1 and RQ1b by monitoring kanji processing before and after the semester for each group and by relating the observations to the kanji writing error analysis. To summarize the key findings by group, eye-tracking data showed that Group 0 (ab-initio learners) showed a significant left-to-right shift in fixation times, with a large reduction in the '*hen*' component accompanied by a large increase in the '*tsukuri*' component. Taken in conjunction with kanji writing error analysis that showed an increase in semantic-type errors, this is evidence that Group 0 are processing semantic radicals more quickly and efficiently than before. The increase in '*tsukuri*' fixation times is most likely caused by the confluence of component position and the challenges of processing components that can contain either semantic or phonological information. Furthermore, the Gaze Plot and Heat Map for Group 0 shows a 'diffuse' gaze, a 'tracing' effect, and longer fixations on specific points. The Non-Kanji errors also showed an increased sensitivity to orthographic details and relatively intact representations of individual components. These patterns taken as a whole suggest that Group 0 have had some success in beginning to develop a processing mechanism that is able to apprehend detailed orthographic information on the level of the component. This can reasonably be considered to be evidence of a burgeoning mechanism of intra-character awareness that is characterized by a facilitation of compositional awareness in kanji.

Fixation time data for Group 1 shows an increase in the '*hen*' component and an increase in the '*tsukuri*' component. With kanji writing error analysis showing little change in semantic errors for this group, the readings are less likely to be attributable to changes in semantic processing. As for the increase in '*tsukuri*' fixation times, the same reasoning for Group 0 applies here, i.e. that the complexity of processing components that may provide either relevant semantic or phonological information places a cognitive burden on the learner, manifesting as longer fixation times on that area of the character. Positioning and frequency effects may also have been relevant. The visualization of data for Group 1 shows a 'centralized' gaze in both PRE and POST data sets, with less evidence of attention being directed to specific points of detail or along individual strokes within characters. Group 1 shows a large increase in Non-Kanji writing error types relating to

components, such as additional or missing strokes. The ‘centralized’ gaze and these types of writing errors appear to show that Group 1 had difficulty adjusting to component analysis, perhaps failing to apprehend the orthographic detail of the components sufficiently to form accurate representations in their memory. It is possible that this difficulty is the result of changing to an unfamiliar learning strategy that required more deliberate effort. Other patterns seen in Group 1, such as a top-down change in fixations and a narrowing effect in enclosed or semi-enclosed characters, may be caused by positional effects but require further study.

The student feedback survey was used to answer RQ1c by gathering data that could offer insights into issues that can impact the successful implementation of component analysis materials in authentic learning environments. One issue that emerged from the survey responses was a positive appraisal of rote-writing exercises, indicating that exercises of this type should be a prime candidate for inclusion in a component analysis approach. It is less clear whether the inclusion of a self-evaluation element with rote writing was effective. The limited number of positive responses mentioning self-evaluation suggests that it did not play a meaningful role from the subjective point of the learners. While this alone does not discount its potential as a useful tool in component analysis, self-evaluation tasks may need to be decoupled from rote-writing tasks so that their role can be properly assessed. Another issue highlighted by the responses was the importance of prescribing a manageable workload and giving clear instructions to students. Findings from the analysis of the kanji decomposition exercises suggest that while participants still considered them to be effective, the workload was too demanding, and the process of decomposition itself could be somewhat confusing. While explicitly decomposing the kanji into its constituent parts has to be a crucial aspect in any component analysis approach, responses make it clear that the tasks must be explained in detail and that the workload is such that the learner does not become overwhelmed. Finally, enjoyment emerged as another significant issue highlighted by the survey. The glyph exercise type appears to have excellent potential in terms of its feasibility in component analysis. The highly customizable nature of the exercise, the possible avenues for teachers to share templates, and the enjoyment of learners at its puzzle-like features make this an attractive candidate

for use in component analysis teaching and learning materials. Overall, responses from the survey indicate that learner's attitudes towards the specific tasks of the exercises may play a vital role in the effective implementation of component analysis. It is crucial to implement the strategy in a way that engages the learner intellectually, makes the process enjoyable and includes aspects that learners find meaningful and perceive as beneficial. Finally, it is vital to offer materials that deliver the technical demands of the component analysis tasks with clarity while maintaining a realistic and manageable workload for the learner.

# 9 Conclusion

## 9.1 Introduction

This study was originally motivated by a personal inquiry into the nature of kanji learning from the perspective of a teacher trying to understand the optimal approaches. Of all the different skills required to acquire proficiency in the Japanese language, learners appeared to struggle with kanji most of all. Their confusion was evident in the questions they asked about kanji and can be summed up in the continuously recurring question ‘What is the best way to learn kanji?’. This is not an easy question for a teacher to answer. In fact, when the question is considered in detail, it becomes a complex conceptual problem that straddles fields such as pedagogy, second language acquisition, cognition, memory, behavioural theories, etc. While there is no shortage of JFL learning strategies and resources available to choose from, including a wide range of textbooks and digital applications, what seemed lacking was empirical data in support of specific strategies that could be adopted by teachers. While anecdotal evidence can be very helpful in language pedagogy, the paucity of empirical support for specific kanji learning strategies can be considered to be sub-optimal, especially in the context of practical application in real classrooms.

To address the problem, this study first presented a broad review of issues in kanji, from learning strategies to cognitive processing to pedagogical implications for LX learners of Japanese. The review identified one specific kanji learning strategy, component analysis, as the most suitable target for a critical analysis. Understanding whether component analysis does actually produce the intended changes in learners that it is supposed to produce became the primary research question of the study. Testing its underlying assumptions is vital if it is to be justifiably used as a means of helping learners to master kanji effectively. This was done in two phases. During PHASE 1, the aim was to fully prepare for designing and implementing component analysis materials by understanding practical issues in classrooms, trends in JFL textbooks, and areas of L1 kanji pedagogy that can be adapted for use in LX environments. PHASE 2 began with the design and subsequent deployment of the component analysis teaching materials. Eye-tracking data and

analysis of kanji writing errors were used to quantify changes in participants' kanji processing accurately and to understand the nature of those changes. A feedback survey was included to highlight areas that could impact the design and use of component analysis in teaching materials, based on the subjective responses from participants.

Section 9.2 presents a synopsis of the key findings of both PHASE 1 and PHASE 2 of the study. Section 9.3 discusses the possible theoretical contributions that this study hopes to have on kanji learning as a whole. This is followed by Section 9.4, which outlines some of the pedagogical implications this study might have for JFL instructors, textbook authors and publishers, education institutions, and kanji learners. Section 9.5 details some of the limitations of this study and the consequences of those limitations. Finally, Section 9.6 suggests some recommendations for areas in which kanji pedagogy could benefit from further research.

## 9.2 Summary of findings

Data collection in PHASE 1 was carried out with the goal of identifying the practical considerations that would inform the design and implementation of component analysis materials in PHASE 2. Findings from the Survey of JFL teachers showed that instructors highlight issues such as time constraints and curriculum demands, motivating students, and dealing with the challenge of teaching visually complex kanji with multiple readings. These challenges force teachers to make practical choices about how to deliver learning outcomes, and it appears that many JFL teachers reluctantly conclude that the de-prioritization of classroom kanji learning is a necessary compromise. Responses made it clear that instructors try to mitigate this perceived disadvantage by relying heavily on teaching materials as a crucial link between the classroom and the self-study environment. Findings from the JFL textbook analysis showed that component-based kanji iterations feature only in a minority of textbooks and that, even when included, it is on a rather limited basis. Despite explicit pedagogical recommendations from studies on L1 and LX

kanji learning alike, which provide evidence that component analysis might have benefits for LX kanji learners, those recommendations do not appear to have manifested in current pedagogical practices, at least in terms of mainstream JFL publications. It is clear that when adopting a component analysis learning strategy, the design or inclusion of original materials to supplement JFL textbooks is necessary. Classroom observations sessions in the domestic Japanese education system provided opportunities to adapt materials and techniques and incorporate them into the design of the ICA Exercises. Overall, the findings of PHASE 1 provided a crucial understanding of how to proceed with the design and implementation of component analysis. It made it clear that the practical reality of teaching kanji in a university would dictate that teaching materials would play a vital role and underscored the need to implement those materials in a way that could account for the possible influence of time constraints, motivation, and kanji complexity. The findings helped to define several criteria for the development of the teaching materials while also providing an understanding of how they can be correctly implemented in real classrooms.

In PHASE 2, component analysis teaching materials were designed and subsequently implemented over the course of a 12-week university semester. Findings from eye-tracking data and an analysis of kanji writing errors indicate that Group 0 shows evidence of more efficient semantic processing of familiar radicals, but they still experienced challenges in processing the unfamiliar components that combined semantic and phonological information. Visualization of data, when considered in tandem with the types of Non-Kanji writing errors made, suggest that Group 0 began to develop an incipient ability to distinguish components, as evidenced by relatively low levels of component-level writing errors and eye-tracking patterns such as the ‘diffuse’ gaze, longer fixations on specific points, and ‘tracing’ effects. It is surmised that component analysis could be a useful strategy for beginners since, after only 12 weeks, these ab-initio learners showed evidence of being able to process kanji in a way that distinguishes components from each other and shows an increased awareness of specific compositional features in the characters. Nevertheless, the problem of having a limited lexicon onto which to map new kanji remains. Group 1 were seen to have difficulty in processing both semantic and phonetic components, as evidenced by increased fixations of both left

and right-positioned components. Visualization of data showing a ‘centralized’ gaze seems to corroborate this conclusion. In addition, the Non-Kanji writing errors of Group 1 shows a very large increase over the semester, especially errors that relate to component-level details. These findings suggest that Group 1, although showing some evidence of increased compositional awareness, experienced considerable difficulty adapting to component analysis. It is speculated that their prior experience of learning kanji may have created challenges adapting to the new learning strategy.

Finally, student feedback responses from both groups indicate that component analysis teaching materials must be carefully calibrated in order to maximize the possible advantages of using the strategy. The materials should include valuable tasks such as rote writing, which recruits motor skills, as well as enjoyable tasks such as puzzle-like glyph exercises, which facilitate learner motivation and positive attitudes. While the materials must include explicit tasks involving kanji decomposition, there is a need to provide detailed instructions and ongoing feedback that can address the challenges that such a complex task entails. Furthermore, the workload and difficulty must be given careful consideration since it was clear they are likely to influence the successful use of the strategy in practical materials.

## 9.3 Theoretical contributions

There are several aspects of this study that attempt to address key areas that influence kanji teaching and learning. It is hoped that the methodology, analysis, and findings of this study can provide theoretical contributions in those areas. The first of these contributions was establishing an accurate overview of the factors that are relevant to the use of component analysis in JFL classrooms and textbooks. The findings from the survey of JFL teachers allowed for a detailed breakdown of the challenges faced by teachers and underscored the importance they place on teaching materials. The analysis of JFL textbooks complements the survey findings by providing a

detailed picture of the usage of component analysis relative to other approaches in current publications. While there is no shortage of studies that examine the processing of components by L1 readers, there is a need for more studies on LX learners in the context of real classrooms in academic institutions. It is hoped that these findings will serve as a useful reference for such future research on how component analysis can be effectively integrated with language modules in academic institutions.

In terms of understanding how component analysis affects kanji processing by $L1^{alpha}$ learners, it is hoped that this study provides a viable framework for using eye-tracking technology to monitor and accurately measure those changes. While eye-tracking has been used extensively in the analysis of dynamic imagery or text at the sentence and word level (especially in alphabetic languages), there is limited data on its use with individual kanji on a full-screen order. The level of detail that eye-tracking data can offer means that there is great potential for its use in a thorough analysis of kanji processing. What has been lacking is an established method for actually implementing this kind of technique. The triangulation of fixation time data with the two types of visualization data used in this study may serve as a possible guide for further research that intends to use eye-tracking to understand processing changes in learners. In this way, it can become possible to establish an empirical foundation on which to base judgements about the overall effectiveness of component analysis, rather than having to rely upon anecdotal evidence.

Finally, in assessing the practical feasibility of using component analysis in teaching materials, this study gathered feedback data from participants. The findings relating to workload, enjoyment, and perceived effectiveness showed the importance of carefully designing the materials to account for task complexity, difficulty, integration with lesson planning, and considering how to engage the learners. This serves as a useful reminder that the materials must always be constructed and employed with the needs of the learners in mind. It is hoped that this study contributes to the ongoing discussion about how to use component analysis materials in a way that engages the

learner and provides them with a sense of benefit while not overburdening them with excessive workloads.

## 9.4 Implications for kanji pedagogy

There are several practical implications of the conclusions in this study, with these implications being contingent upon the completion of future research that supports the findings within. One implication is that beginner-level learners could benefit from the early adoption of a component analysis strategy for learning kanji. This study suggests that even a relatively short 12-week period is sufficient to begin showing evidence that learners can develop the skill of being aware of detailed orthographic elements in the characters, allowing them to perceive the kanji as collections of components rather than a confusing jumble of unrelated strokes. This suggests that component analysis may be suited to beginner learners who can adapt to it quickly if provided with sufficiently clear instruction. If such a pedagogical approach was successful, it might be a valuable tool in developing overall reading proficiency, with learners being guided from the outset towards a processing mechanism that can efficiently decode both semantic and phonological information from kanji. While the task of learning kanji would still be complex and extremely challenging, if learners are better able to recognise familiar components and extract information from them on that basis, it could equip them with a reliable method for making systematic progress in their kanji studies. As discussed above, there are many possibilities for the inclusion of digital applications in this process.

There are also implications for learners with prior kanji experience. Findings in this study indicate that Group 1, a group of lower-intermediate learners with approximately one to two years of prior kanji learning experience, had difficulty adapting to component analysis. It appears that switching to this strategy may have caused confusion. What is not clear is how much longer it would have

taken for them to readjust to this new strategy. Therefore, there is a need for further research and data that explores the effects of switching and adjusting to new kanji learning strategies, examining the impact this could have over time. Nevertheless, findings from this study indicate that there is a period of adjustment in which the learner might experience some difficulties as they try to change to an unfamiliar learning strategy. This should be noted by teachers or learners who switch to a component analysis approach.

In terms of implications for teachers, what emerged from PHASE 1 was a clear picture of the critical importance that teachers place on teaching materials. While aspects of teaching such as classroom time constraints, curriculum demands, module learning outcomes, and examination formats may not change in the short term, there is more scope for adapting teaching materials to incorporate learning strategies such as component analysis. Understanding these factors provided the rationale for the design of Intra-Character Awareness Exercises in this study. These exercises could be further developed if enough teachers combined resources and shared materials such as worksheet templates. If this kind of cooperation was successful, the creation of original teaching materials would be less time-consuming and could become a genuinely feasible element of kanji teaching. In keeping with the findings from the student feedback survey in this study, any such original teaching materials should strive to create an optimal balance between workload and enjoyment. Teachers should also be aware that textbook selection may be an issue that deserves scrutiny. If the de-prioritization of kanji learning is something that teachers want to avoid, they must be made aware that their choice of textbook might have an influence on kanji learning, with only a small range of textbooks containing component analysis, for example.

As for specific practical implications, the digital applications used to create the Intra-Character Awareness Exercises may be a useful reference tool for JFL teachers, allowing them to understand practical methods of generating customisable teaching materials. For example, the inclusion of free-to-use digital applications to generate rote-writing worksheets or kanji glyph materials was an

attempt to ground the strategy in practicality. As seen in Chapter 6, the highly customisable nature of these applications means there is huge scope for teachers to experiment and share materials among peers. It is hoped that the successful employment of these techniques might serve as a basis on which to continue research that explores the options available in implementing component analysis. An ongoing evaluation of component analysis as a learning strategy will necessarily involve gathering more data from classrooms. The design of ICA Exercises can provide a reference point for generating teaching materials that enact component analysis in a way that allows it to be integrated into current curricula.

On a topic related to the above point, if further research can establish that component analysis does indeed offer tangible benefits for learners, the findings in this study will have implications for publishers of JFL textbooks. The standard publications that featured as source materials for analysis in this study were shown to have a strong preference for references and exercises that are dominated by single-character and compound-word types. While there is no evidence to suggest that there is anything wrong with their inclusion as a mainstay in kanji learning, it may be possible to strengthen the contribution of component analysis in the learning process by including more references or productive exercises that test the learner's knowledge of components as well as single characters or compound words.

## 9.5 Limitations of this study

The first limitation to be considered is the sample size in the study. The two groups in PHASE 2 of the study involved a total of 26 participants. While data from all participants was used in the kanji writing error analysis, the eye-tracking used 11 participants for fixation time data and 8 participants for the visualization of data (four from each group), with the student feedback survey having 19 respondents. Overall, the sample size can be considered to be somewhat small. Findings and

conclusions should be considered in the context of this sample size, and it is acknowledged that further research with larger sample sizes is indicated.

Another limitation that was unavoidable relates to the length of the study. Since it happened over the course of twelve weeks, the possibility exists that confounding factors may have been introduced by the individual differences in the study plans of the participants. Using a prolonged time frame increases the likelihood of an error margin in the data because each participant may have used different kanji learning strategies beyond the confines of the curriculum workload. While one student may complete the minimal coursework, another may be using a variety of other strategies to supplement their classwork. The number of additional hours of study may vary among individuals. While it may have been possible to attempt to track such additional hours by asking participants to log their study hours, it was considered unrealistic as an option. Therefore, the findings of the study must be understood in the context of a possible margin of error introduced by using a twelve-week period. Again, this is a difficulty that is not easy to overcome. Kanji learning is necessarily a process that takes large amounts of time, and any type of longitudinal research will always run the risk of introducing potentially confounding factors with the inability to control for individual differences among students.

The use of statistical analyses in this study resulted in some limitations. The application of multiple t-tests in both the eye-tracking data analysis and the student feedback survey was a necessary step in attempting to establish reliable comparisons between groups and between time points. However, using multiple t-tests can be problematic and is a known issue that has been discussed in the statistical literature, with the likelihood of erroneous results increasing as the number of employed tests increases. Similarly, data sets that contain multiple variables, as is the case in Section 7.3.2, can create challenges in correctly interpreting the observed differences between the variables. A statistical technique like Factor Analysis might be a possible solution in aiming to clarify the underlying correlations between the variables. In this study, Factor Analysis was not used due to

the limited sample size. However, it is acknowledged that both the use of multiple t-tests and not using a correctional technique like Factor Analysis is a limitation of this study.

Using eye-tracking to monitor changes in kanji processing also resulted in some limitations. In order to control for factors such as visual complexity and frequency, the available curriculum kanji were winnowed to a smaller subset. Appendix F shows the finalised list, which contains a mixture of compound ideographs and phonetic characters. Ideally, only characters of the same category would be used in the analysis. However, with limited amounts of characters available, doing so would have resulted in a final list of only 15 kanji or less. This number was deemed to be too small to provide any meaningful data, and the list was expanded to include both phonetic and compound ideographic characters. In addition, the visualization of data (Heat Map and Gaze Plot) is not straightforward to interpret. The design of a visual matrix was done to provide a reliable method to perform visual comparisons for each individual kanji. Nonetheless, it must be conceded that a qualitative analysis of such data has the potential to introduce a margin of error based on the researcher's perceptions and interpretation of the data. Triangulation of quantitative data with the two types of visualization data was used in order to minimize the risk of such errors.

One limitation of the Survey of JFL Teachers is that the survey was conducted in English only, for practical reasons. It was anticipated that respondents would be living in countries where Japanese was being taught as a foreign language and that both teachers and learners would be able to communicate freely in English. The findings of the survey show that at least 29 respondents were not native speakers of English. Therefore, it is acknowledged that these respondents may have been able to provide more detailed feedback if the survey had been provided in their native Japanese language as well as in English.

## 9.6 Recommendations for further study

The topic of kanji learning is an expansive one that straddles multiple disciplines, making it a very complex object of investigation. The scope of this study was necessarily confined to specific parameters to avoid the risk of diluting its theoretical importance by trying to include everything at once. In selecting component analysis as the primary target of observation, other learning strategies had to be placed aside. The overarching goal of most research on LX kanji learning is to understand how learners can learn kanji more effectively, allowing them to manage the challenges in becoming proficient in kanji successfully. Answering the question of which strategy or combination of strategies is best is the ultimate aim of this field of research. As such, component analysis must continue to be evaluated in a thorough and objective manner. This study provides context on its use in classrooms and textbooks, as well as data on changes in processing that can be attributable to it. In terms of assessing the factors that impact the implementation of component analysis, this study relied on subjective feedback from the participants. Future research must identify additional methods of investigation that can objectively evaluate the potential of component analysis relative to other learning strategies.

The use of eye-tracking in experimental research suggests itself as an area that could eventually yield benefits to kanji learners. The sample size in this study was small, making it necessary to rely mainly on qualitative analysis and triangulation to interpret the causal factors in the findings. The use of larger sample sizes in eye-tracking would allow for robust statistical analyses that have the potential to advance the theoretical discussion on kanji processing in LX learners. Such testing would have to be carefully controlled in terms of source materials and methodologies, but there is great scope for its inclusion in future research.

The topic of using digital applications to assist learners with component analysis was mentioned briefly in this study. This is an area in which there appear to be numerous possibilities for integrating modern technology into existing learning strategies. Harnessing the power of digital

applications has the potential to provide the learner with an experience that accentuates the core aims of a task while removing the superfluous elements that might detract from the process. For example, it was seen in this study that kanji decomposition exercises were sometimes perceived as being convoluted or confusing. A digital application could be used to streamline the learning process by removing unduly complex parts of the task, allowing the learner to focus on the primary exercise of separating the constituent components. Research on how to successfully integrate such digital applications into the learning process would enable the development of such applications.

Finally, the question of how to adapt and integrate L1 learning strategies into the LX context could be explored further. The ongoing debate about differences between L1 and LX in terms of language acquisition can be set aside in pedagogical discussions if the focus is shifted to practical questions of what can be used to good effect between them. The assumptions about differences between L1 and LX must be reassessed with more pragmatic goals in mind. There is scope for future research to explore how processing mechanisms can overlap between these groups and to test how learning strategies can be adapted to serve LX based on the similarities in processing rather than the differences.

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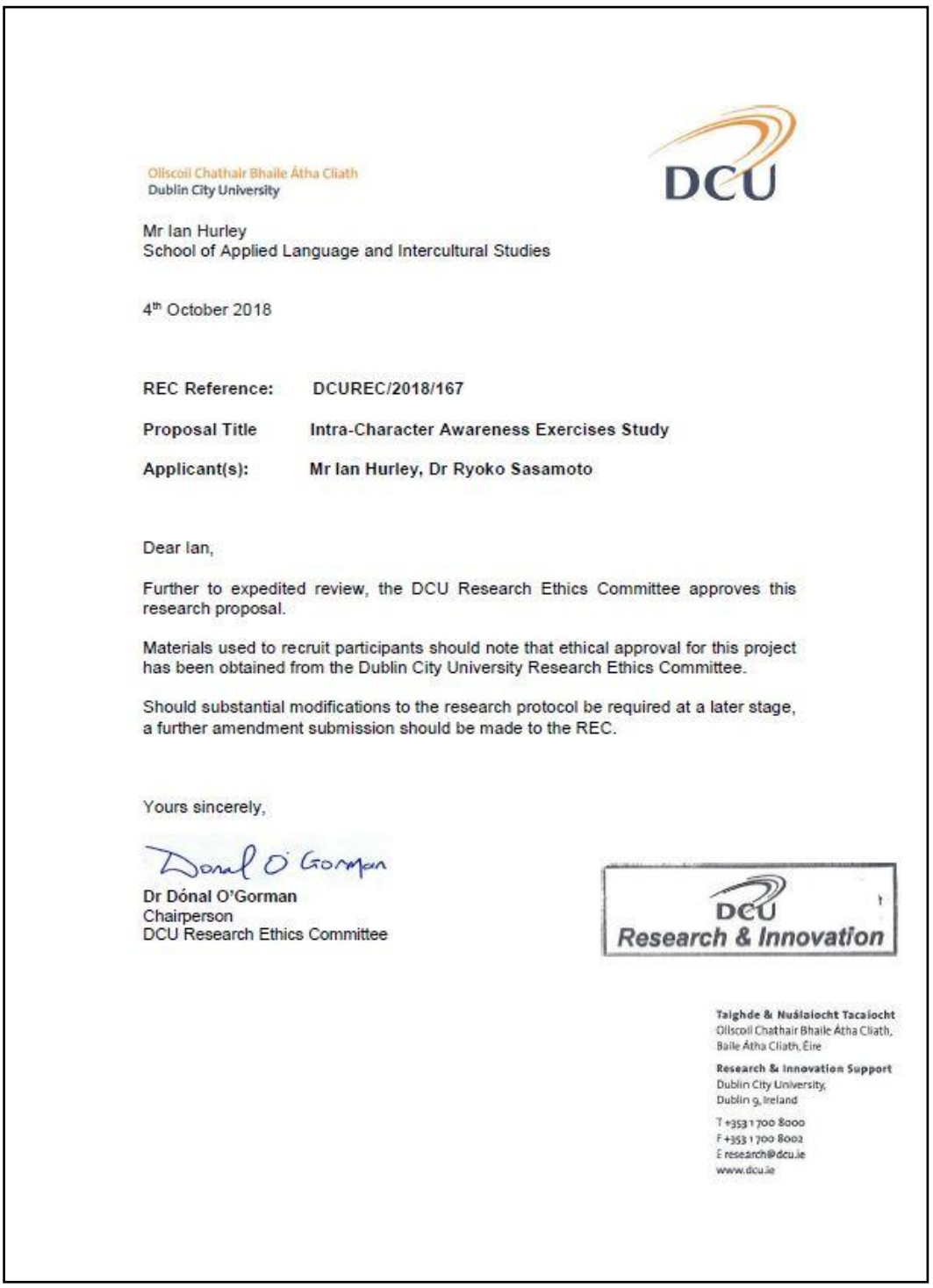
# 11 Appendices

## 11.1 Appendix A: Research ethics committee approval letter

Below is a copy of a letter that was issued by the DCU Research Ethics Committee to the Principal Investigator in this study. The letter contains the official approval reference code, which indicates that the proposal conforms to the research ethics regulations of the institution.



Ollscoil Chathair Bhaile Átha Cliath
Dublin City University

DCU

Mr Ian Hurley
School of Applied Language and Intercultural Studies

4th October 2018

**REC Reference:** DCUREC/2018/167

**Proposal Title** Intra-Character Awareness Exercises Study

**Applicant(s):** Mr Ian Hurley, Dr Ryoko Sasamoto

Dear Ian,

Further to expedited review, the DCU Research Ethics Committee approves this research proposal.

Materials used to recruit participants should note that ethical approval for this project has been obtained from the Dublin City University Research Ethics Committee.

Should substantial modifications to the research protocol be required at a later stage, a further amendment submission should be made to the REC.

Yours sincerely,

Donal O' Gorman

**Dr Dónal O'Gorman**
Chairperson
DCU Research Ethics Committee

DCU
Research & Innovation

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## 11.2 Appendix B: Research integrity plain language statement

Below is a copy of the Plain Language Statement that was provided to potential participants before the beginning of the study. It describes the details of the study and provides information on confidentiality policies.

**Plain Language Statement - "Intra Character Awareness Exercises"**

**About this study:**
The purpose of this study is to test a set of teaching exercises which aim to make learning Japanese kanji characters more efficient. The exercises are called Intra-Character Awareness Exercises (ICA). ICA Exercises are based on empirical studies which recommend that learners of kanji, especially those whose native language is alphabet-based, could benefit from having a greater awareness of the smaller subcomponents within the characters. ICA Exercises are designed to draw attention to these subcomponents by using a combination of reading and writing exercises which target the eye on individual areas within the characters. ICA also contains a "Kanji Learning e-Portfolio", in which learners document their kanji learning progress as they use the exercises. The aim of the portfolio is to help learners develop a successful self-study program.

**Details of involvement in the study:**
Participants in this study will be DCU students who are taking Japanese language modules. They will complete one Japanese language module as per the module description, with the same learning outcomes. The main difference will be that the kanji portion of the module will use Intra-Character Awareness exercises instead of traditional rote-learning techniques. Participants will also be required to write six entries in a Kanji Learning e-Portfolio and submit the entries as part of the module assessment. The effectiveness of ICA Exercises will be evaluated by comparing test scores from the end-of-term test with scores from previous tests in which standard kanji teaching methods were used. A small sample of participants will also be asked to volunteer to take part in eye-tracking studies before and after the study, to establish whether reading patterns have changed during the study.

**Confidentiality and use of data:**
Protecting the privacy of all participants is the highest priority. Therefore, all the data collected in this study will be rendered completely anonymous. Any personal information will be removed from the data prior to analysis. The data will then be used in a PhD thesis which will discuss the effectiveness of the teaching exercises used in the study. The data will be encrypted and stored on local servers at Dublin City University for a period of four years, after which it will be securely deleted. It must be noted that protection of this data is subject to legal limitations. It is possible for data to be subject to subpoena, freedom of information claims or mandated reporting by some professions.

**Benefits:**
Students in this study are likely to benefit from learning kanji by using ICA exercises. There is solid evidence which suggests that altering reading patterns to focus on subcomponents could greatly help students with the challenging task of learning kanji. Students will also be encouraged to proactively evaluate their own kanji learning progress. This can often be of great benefit because it can promote motivation and generate positive attitudes towards learning kanji.

**Risks:**
There are no foreseen risks to anyone participating in the study. All data will be rendered anonymous and confidentiality will be given utmost priority. In addition, the module content will be taught by a teacher with years of professional experience of teaching in universities.

Involvement in the study is voluntary. Participants may withdraw from the study at any point.

## 11.3 Appendix C: Research integrity informed consent form

Below is a copy of the Informed Consent forms that participants submitted when agreeing to take part in the study.

This was reviewed and approved by the DCU Research Ethics Committee.

**Informed Consent Form - "Intra-Character Awareness Exercises" (ICA)**

Study title: "Intra-Character Awareness Exercises" (ICA).
Location: The School of Applied Language and Intercultural Studies at Dublin City University (Dublin, Ireland).
Principal Investigator: Mr Ian Hurley
Contact details: ian.hurley4@mail.dcu.ie

**Purpose of research**
The purpose of this study is to evaluate a set of teaching exercises which aim to make learning Japanese kanji characters more efficient. This will be done by teaching the kanji portion of a Japanese language module using "Intra-Character Awareness Exercises".

**Confirmation**

*Participant – please complete the following (Circle Yes or No for each question)*

| | | |
|---|---|---|
| *I have read the Plain Language Statement (or had it read to me)* | *Yes* | *No* |
| *I understand the information provided* | *Yes* | *No* |
| *I have had an opportunity to ask questions and discuss this study* | *Yes* | *No* |
| *I have received satisfactory answers to all my questions* | *Yes* | *No* |
| *I am aware that the Principal Instigator is the lecturer of the module* | *Yes* | *No* |
| *I am aware that data from tests may be used to evaluate the teaching materials* | *Yes* | *No* |
| *I am aware that I may volunteer to take part in eye-tracking studies* | *Yes* | *No* |
| *I am aware that all data gathered in this study will be made anonymous* | *Yes* | *No* |
| *I am aware that I may withdraw from the study at any point* | *Yes* | *No* |

**Signature:**

I have read and understood the information in this form. My questions and concerns have been answered by the researchers, and I have a copy of this consent form. Therefore, I consent to take part in this research project

**Participants Signature:** _____

**Name in Block Capitals:** _____

**Date:** _____

## 11.4 Appendix D: Survey of JFL teachers sample survey questions

Section A: Teaching Environment

- What are the main learning outcomes of the course you teach?
- What type of course do you teach?
- How many kanji (approximately) do you teach in one academic year?
- How are your students assessed?

Section B: Teaching Materials

- Please indicate the primary textbook you use to teach kanji. (e.g. Genki, Basic Kanji, Marugoto, etc.)
- How would you rate that textbook's treatment of kanji? Please explain why you gave the textbook this rating.
- What kind of supplementary materials do you use to teach kanji?
- Which websites (if any) do you use as part of your teaching of kanji? (e.g. Quizlet, Edmodo, etc.)

Section C: Teaching Methods

- On average, how much time of each class do you spend on kanji?
- What kind of audio-visual materials do you use when you teach kanji?
- Do you teach the meaning of kanji radicals separately from the whole character?
- Which part of the writing system do you teach first?
- Do you usually use mnemonics to help teach kanji?
- Do you teach kanji on a whole-word basis or an individual-character basis?
- What kind of written exercises do you prefer when teaching kanji?

Section D: Teacher Attitudes

- In your opinion, how important is kanji for learning new vocabulary?
- In your opinion, how important is the skill of writing kanji?
- In your opinion, what do your students find most challenging about learning kanji?
- What do you think are the biggest obstacles you face when teaching kanji?

Section E: General

- What improvements might you suggest to someone designing new teaching materials for teaching kanji?
- Please indicate below how important you believe the following issues are in relation to teaching kanji.
  Student motivation, textbooks, supplementary materials, character complexity, homework.
- Please feel free to offer any comment on anything to do with teaching/learning kanji which you feel this survey does not address.

## 11.5 Appendix E: List of JFL textbooks used as source materials for analysis


Association for Japanese Language Teaching. (1990). *Japanese for Busy People 2*. Tokyo: Kodansha International.

Association for Japanese Language Teaching. (2016). *Practical Kanji: An Introductory Kanji Textbook for Japanese Language Learners, Vol.1*. Tokyo: Ask Publishing.

Banno, E., Ikeda, Y., Shinagawa, C., Tajima, K., & Tokashiki, K. (2009). *Kanji Look and Learn Workbook*. Tokyo, Japan: The Japan Times.

Banno, E., Yutaka, O., & Yoko, S. (1999). *Genki: An integrated course in elementary Japanese*. Tokyo: The Japan Times.

Chieko, K., Shimizu, Y., Yakenaka, H., & Ishii, E. (1989). *Basic Kanji Book Volume 2*. Tokyo: Bonjinsha Co. Ltd.

Hadamitzky, W., & Spahn, M. (2003). *A Guide to Writing Japanese Kanji & Kana*. Clarendon: Tuttle Publishing.

Heisig, J. W. (2007). *Remembering the Kanji: A Systematic Guide to Reading Japanese Characters* (Vol. 4). Honolulu: University of Hawaii Press.

Kano, C., Takenaka, H., Ishii, E., & Shimizu, Y. (1989). *Basic Kanji, Volume 1*. Tokyo, Japan: Bonjinsha Co. Ltd.

Kijima, H., Shibahara, T., & Hatta, N. (2013). *Marugoto Introduction A1*. Tokyo: Sanshusha Publishing.

Kijima, H., Shibahara, T., Hatta, N., Imai, T., & Kitani, N. (2014). *Marugoto Shokyu 1 A2*. Tokyo: Sanshusha Publishing.

Kijima, H., Shibahara, T., Hatta, N., Kitani, N., & Netsu, M. (2014). *Marugoto Shokyu 2 A2*. Toyko: Sanshusha Publishing.

Koyama, S. (2007). *J-Bridge for Beginners Volume 1*. Toyko: Bonjiinsha.

Kurasawa, K., Kigami, T., & Shibuya, M. (2010). *Nihongo Challenge Kanji N4 N5*. Tokyo, Japan: Ask Publishing.

Makino, S., Abe Hatasa, Y., & Hatasa, K. (1998). *Nakama 1 : Japanese communication, culture, context*. Boston: Houghton Mifflin.

Mitamura, J. K., & Mitamura, Y. K. (1997). *Let's Learn Kanji: An Introduction to Radicals, Components and 250 Very Basic Kanji*. Tokyo, Japan: Kodansha International Ltd.

Nishiguchi, K., & Tamaki, K. (1996). *Kanji in Context*. Tokyo: Nippon Shuppan Hanbai.

Ogawa, I. (1998). *Minna no nihongo*. Tokyo: 3A Corporation.

Oka, M., Tsutsui, M., Kondo, J., Emori, S., Hanai, Y., & Ishikawa, S. (2009). *Tobira: Gateway to Advanced Japanese*. Tokyo: Kurosio Publishers.

Sasaki, H., & Sato, N. (2014). *Ryuugakusei no tame no kanji, Beginner 300* (2nd ed.). Tokyo: Kokusho kankokai.

Shinya, M., Koga, C., Takada, R., & Mikogami, K. (2001). *Minna no Nihongo Shokyu 1 Kanji Workbook*. Tokyo, Japan: 3A Corporation.

Stout, T. G., & Hakone, K. (2017). *Japanese Kanji for Beginners: (JLPT Levels N5 & N4)*. Tokyo: Tuttle.

Trombley, G., Hatanaka, K., Takenaka, Y., & McGowan, J. (2016). *Kanji From Zero! (Book 1)*. Kent: Bay Foreign Language Books Ltd.

Zimmerman, U. (2007). *Nihongo Kantan*. Dublin: Department of Education and Skills, Ireland.

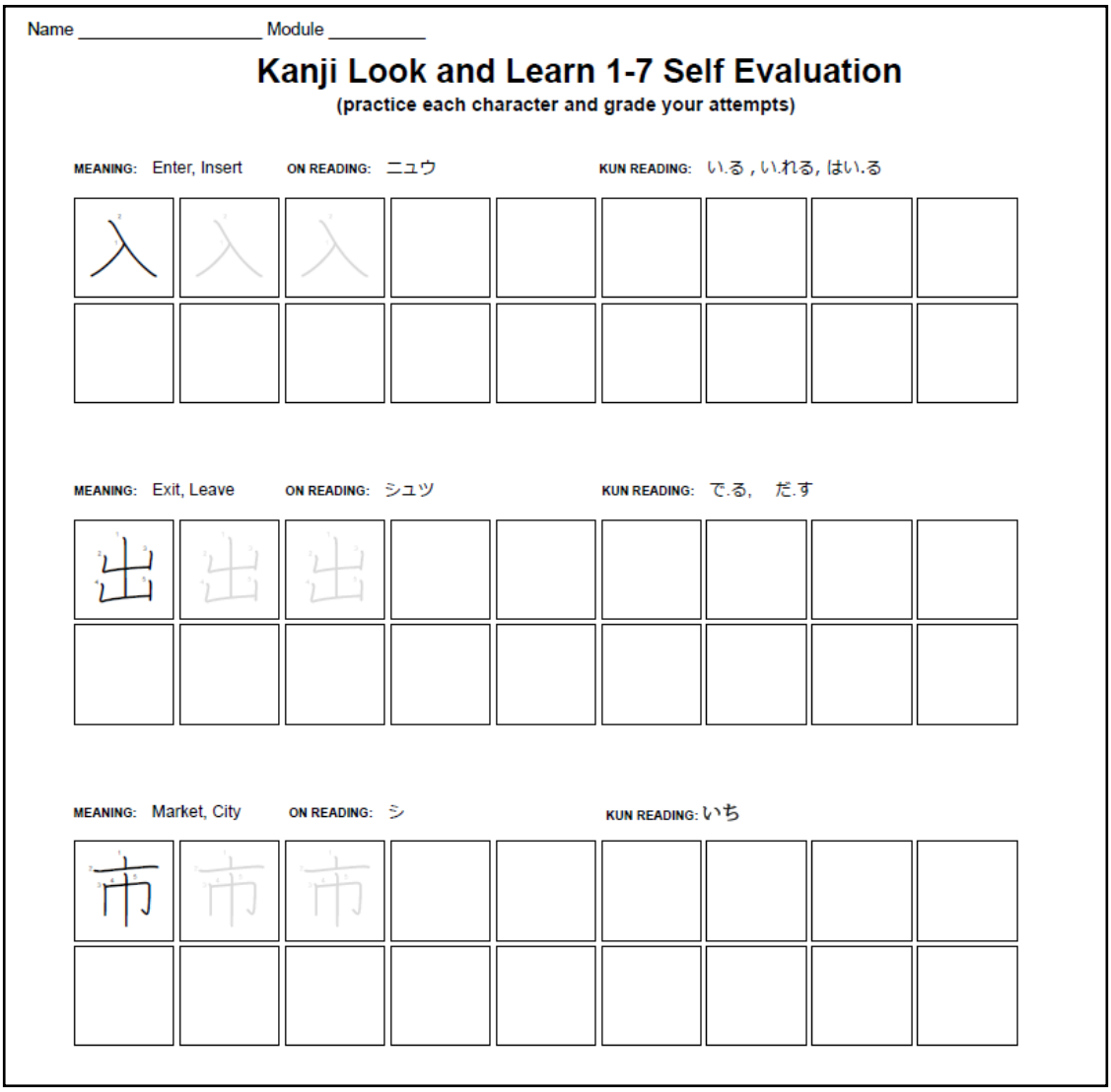
## 11.6 Appendix F: Eye-tracking source materials

Below is a list of the kanji characters used as a stimulus for eye-tracking, with controls indicated.

| id | Kanji | Strokes | Kanji Classification | # of On | of Kun within Joyo with inflection | Kanji Frequency with Proper Nouns | Symmetry |
|---|---|---|---|---|---|---|---|
| 1926 | 名 | 6 | 会意 Com. Ideographic | 2 | 1 | 291373 | S |
| 365 | 休 | 6 | 会意 Com. Ideographic | 1 | 3 | 57608 | S |
| 1348 | 男 | 7 | 会意 Com. Ideographic | 2 | 1 | 268685 | S |
| 1622 | 売 | 7 | 会意 Com. Ideographic | 1 | 2 | 214276 | S |
| 661 | 国 | 8 | 会意 Com. Ideographic | 1 | 1 | 1703390 | S |
| 1928 | 明 | 8 | 会意 Com. Ideographic | 2 | 9 | 626629 | S |
| 1953 | 夜 | 8 | 会意 Com. Ideographic | 1 | 2 | 70624 | S |
| 891 | 秋 | 9 | 会意 Com. Ideographic | 1 | 1 | 78078 | S |
| 1384 | 昼 | 9 | 会意 Com. Ideographic | 1 | 1 | 14793 | S |
| 1061 | 森 | 12 | 会意 Com. Ideographic | 1 | 1 | 117996 | S |
| 1628 | 買 | 12 | 会意 Com. Ideographic | 1 | 1 | 79473 | S |
| 55 | 飲 | 12 | 会意 Com. Ideographic | 1 | 1 | 33925 | S |
| 808 | 寺 | 6 | 形声 Phonetic | 1 | 1 | 41334 | S |
| 842 | 社 | 7 | 形声 Phonetic | 1 | 1 | 720650 | S |
| 1279 | 村 | 7 | 形声 Phonetic | 1 | 1 | 248650 | S |
| 817 | 持 | 9 | 形声 Phonetic | 1 | 1 | 323708 | S |
| 1297 | 待 | 9 | 形声 Phonetic | 1 | 1 | 116127 | S |
| 930 | 春 | 9 | 形声 Phonetic | 1 | 1 | 87078 | S |
| 818 | 時 | 10 | 形声 Phonetic | 1 | 1 | 835363 | S |
| 623 | 校 | 10 | 形声 Phonetic | 1 | 0 | 226338 | S |
| 317 | 起 | 10 | 形声 Phonetic | 1 | 3 | 143238 | S |
| 1726 | 病 | 10 | 形声 Phonetic | 2 | 2 | 129313 | S |
| 1816 | 勉 | 10 | 形声 Phonetic | 1 | 0 | 18963 | S |
| 898 | 週 | 11 | 形声 Phonetic | 1 | 0 | 82692 | S |
| 1679 | 晩 | 12 | 形声 Phonetic | 1 | 0 | 7374 | S |

## 11.7 Appendix G: Samples of Intra-Character Awareness Exercises (a)

Self-assessed kanji writing exercises



Name _____ Module _____

**Kanji Look and Learn 1-7 Self Evaluation**

**(practice each character and grade your attempts)**

**MEANING:** Enter, Insert **ON READING:** ニュウ **KUN READING:** い.る , い.れる, はい.る

**MEANING:** Exit, Leave **ON READING:** シュツ **KUN READING:** で.る, だ.す

**MEANING:** Market, City **ON READING:** シ **KUN READING:** いち

## 11.8 Appendix H: Samples of Intra-Character Awareness Exercises (b)

Kanji decomposition exercises

Name _____ Kanji Look and Learn 7

### Decompose Kanji Lesson 7

*(a) Rewrite the individual subcomponents of each kanji below (https://www.kanshudo.com/search )*
*(b) For each subcomponent, write any other kanji you know which contains that subcomponent.*
*(c) Write any full words you know that contain this kanji.*

| | | | | |
|---|---|---|---|---|
| 例 | 話 | (a) 話 ＝ 言＋舌 | (b) 記, 訂, 乱, 舌 | (c) 話す, 電話 |
| | 入 | (a) _____ | (b) _____ | (c) _____ |
| | 出 | (a) _____ | (b) _____ | (c) _____ |
| | 市 | (a) _____ | (b) _____ | (c) _____ |
| | 町 | (a) _____ | (b) _____ | (c) _____ |
| | 村 | (a) _____ | (b) _____ | (c) _____ |
| | 雨 | (a) _____ | (b) _____ | (c) _____ |
| | 電 | (a) _____ | (b) _____ | (c) _____ |
| | 車 | (a) _____ | (b) _____ | (c) _____ |

## 11.9 Appendix I: Samples of Intra-Character Awareness Exercises (c)

Kanji glyph exercises

Name _____ Kanji Look and Learn – Lesson 8

# 漢字構造 8

*Each character below has a mistake of some kind.*

**Step 1: Study!** *Study kanji on the left and identify the error(s). Use the readings and meaning to help.*
**Step 2: Attempt!** *Attempt to write the character correctly.*
**Step 3: Check!** *Check the correct version by referring to a dictionary or textbook.*
**Step 4: Practice!** *Practice the correct version 3 times.*

| Mistake | Kun-yomi | On-yomi | Meaning | Attempt | Correct | Writing Practice | | |
|---|---|---|---|---|---|---|---|---|
| 詁 例 | はなし | ワ | talk | 言吾 x | 話 ✓ | 話 | 話 | 話 |
| 木 | やす-む | キュウ | rest | | | | | |
| 丰 | はし-る | ソウ | run | | | | | |
| 走 | お-きる | キ | get up | | | | | |
| 只 | かい | | shellfish | | | | | |
| 罒 | か-う | バイ | buy | | | | | |
| 売 | う-る | バイ | sell | | | | | |
| 売 | よ-む | ドク | read | | | | | |
| 聿 | か-く | ショ | write | | | | | |
| 帰 | かえ-る | キ | return | | | | | |
| 免 | | ベン | effort | | | | | |
| 勹 | ゆみ | キュウ | bow | | | | | |

## 11.10 Appendix J: Student feedback survey questions

**Section 1: Self-assessed writing exercises (Likert scale)**

These exercises were easy to understand.

These exercises were interesting.

These exercises could be finished quickly.

These exercises helped me read kanji.

These exercises helped me write kanji.

I enjoyed doing these exercises.

I would like to continue using Self-Assessed Writing exercises to learn kanji.

Please offer your honest opinion on any aspect of the Self-Assessed Writing Exercises.

**Section 2: Kanji decomposition exercises (Likert scale)**

These exercises were easy to understand.

These exercises were interesting.

These exercises could be finished quickly.

These exercises helped me read kanji.

These exercises helped me write kanji.

I enjoyed doing these exercises.

I would like to continue using Decomposing Kanji exercises to learn kanji.

Please offer your honest opinion on any aspect of the Decomposing Kanji exercises.

**Section 3: Kanji glyph exercises (Likert scale)**

These exercises were easy to understand.

These exercises were interesting.

These exercises could be finished quickly.

These exercises helped me read kanji.

These exercises helped me write kanji.

I enjoyed doing these exercises.

I would like to continue using kanji glyph exercises to learn kanji.

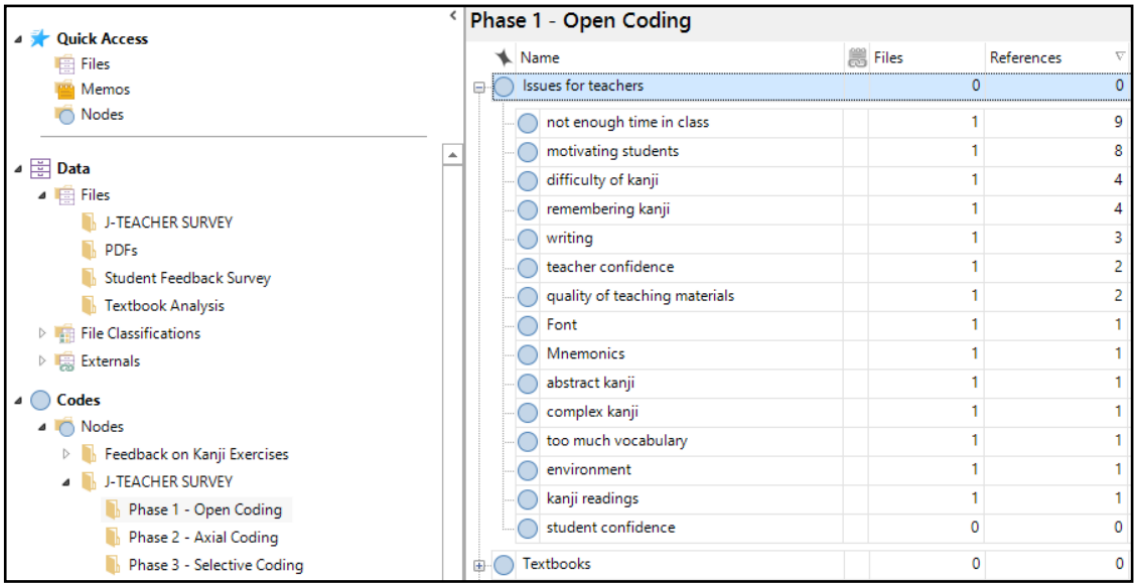
Please offer your honest opinion on any aspect of the kanji glyph exercises.

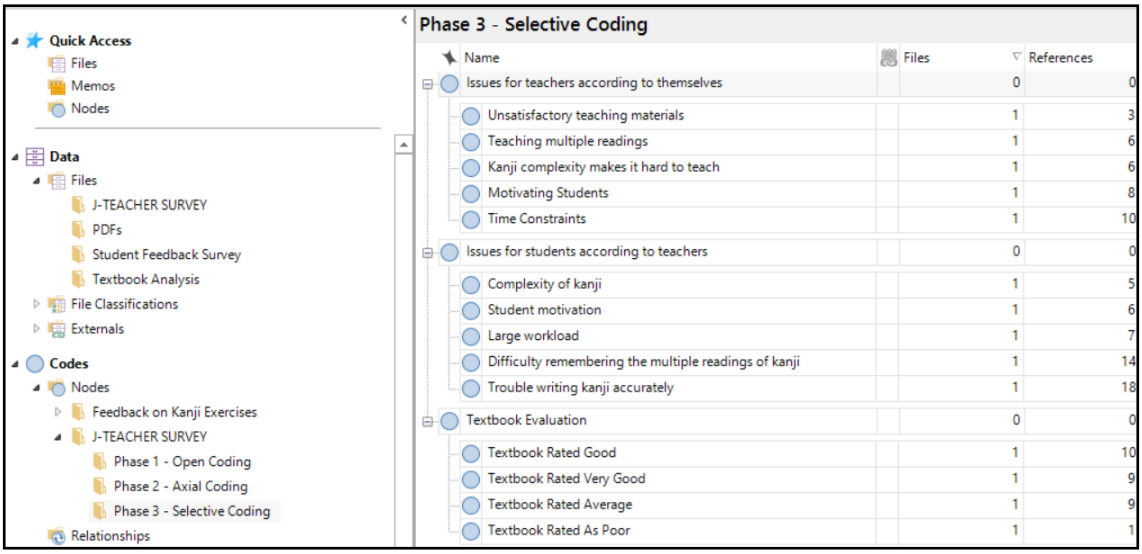
**Section 4: General**

Please offer any other feedback or comments relating to the kanji exercises above.

## 11.11 Appendix K: Nvivo 12 Pro (QSR International) coding samples

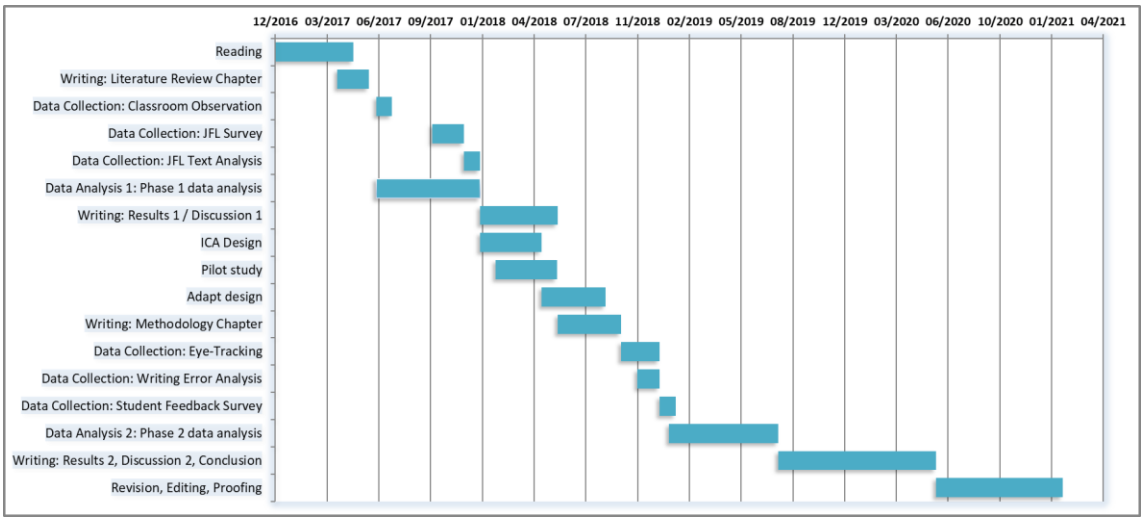
Below are screenshots from Nvivo 12 Pro, showing a sample of the process of Open Coding and Selective Coding stages, with data nodes generated in the analysis of data from a survey of JFL teachers.



## 11.12 Appendix L: Research timeline

Below is a graphical representation of the complete timeline of the stages in the study.



## 11.13 Appendix M: Student feedback survey t-tests

Below are the results of t-tests for each category of exercise in Intra-Character Awareness Exercises, showing no statistically significant responses between groups.

*Independent samples t-test for Self-assessed kanji writing exercises*

| | | t-test for Equality of Means | | |
|---|---|---|---|---|
| SELF-ASSESSED WRITING | t | df | Sig. (2-tailed) | Difference |
| A: These exercises were easy to understand. | -0.378 | 17 | 0.710 | -0.239 |
| | -0.396 | 16.959 | 0.697 | -0.239 |
| A: These exercises were interesting. | -0.116 | 17 | 0.909 | -0.068 |
| | -0.134 | 12.200 | 0.896 | -0.068 |
| A: These exercises could be finished quickly. | -0.266 | 17 | 0.793 | -0.193 |
| | -0.278 | 16.943 | 0.784 | -0.193 |
| A: These exercises helped me read kanji. | 0.910 | 17 | 0.376 | 0.636 |
| | 0.878 | 13.122 | 0.396 | 0.636 |
| A: These exercises helped me write kanji. | -0.574 | 17 | 0.574 | -0.307 |
| | -0.530 | 10.629 | 0.607 | -0.307 |
| A: I enjoyed doing these exercises. | 0.287 | 17 | 0.778 | 0.182 |
| | 0.329 | 12.513 | 0.747 | 0.182 |
| A: I would like to continue using Self Assessed writing exercises to learn kanji. | -0.679 | 17 | 0.507 | -0.534 |
| | -0.661 | 13.704 | 0.520 | -0.534 |

*Independent samples t-test for kanji decomposition exercises*

| | t-test for Equality of Means | | | |
|---|---|---|---|---|
| DECOMPOSING KANJI | t | df | Sig. (2-tailed) | Mean Difference |
| B: These exercises were easy to understand. | 0.386 | 17 | 0.705 | 0.318 |
| | 0.396 | 16.493 | 0.697 | 0.318 |
| B: These exercises were interesting. | -0.828 | 17 | 0.419 | -0.636 |
| | -0.875 | 16.997 | 0.394 | -0.636 |
| B: These exercises could be finished quickly. | -1.156 | 17 | 0.264 | -0.511 |
| | -1.330 | 12.258 | 0.208 | -0.511 |
| B: These exercises helped me read kanji. | -1.025 | 17 | 0.320 | -0.761 |
| | -0.959 | 11.299 | 0.358 | -0.761 |
| B: These exercises helped me write kanji. | -1.413 | 17 | 0.176 | -0.977 |
| | -1.279 | 9.648 | 0.231 | -0.977 |
| B: I enjoyed doing these exercises. | -0.405 | 17 | 0.691 | -0.284 |
| | -0.391 | 13.248 | 0.702 | -0.284 |
| B: I would like to continue using Decomposing kanji exercises to learn kanji. | -1.137 | 17 | 0.271 | -1.023 |
| | -1.106 | 13.600 | 0.288 | -1.023 |

*Independent samples t-test for kanji glyph exercises*

| | t-test for Equality of Means | | | |
|---|---|---|---|---|
| KANJI GLYPHS | t | df | Sig. (2-tailed) | Mean Difference |
| C: These exercises were easy to understand. | 0.173 | 17 | 0.865 | 0.080 |
| | 0.194 | 14.345 | 0.849 | 0.080 |
| C: These exercises were interesting. | 0.348 | 17 | 0.732 | 0.261 |
| | 0.373 | 16.811 | 0.714 | 0.261 |
| C: These exercises could be finished quickly. | -0.173 | 17 | 0.864 | -0.125 |
| | -0.186 | 16.758 | 0.854 | -0.125 |
| C: These exercises helped me read kanji. | 0.793 | 17 | 0.439 | 0.659 |
| | 0.842 | 16.976 | 0.412 | 0.659 |
| C: These exercises helped me write kanji. | 1.392 | 17 | 0.182 | 0.625 |
| | 1.559 | 14.518 | 0.141 | 0.625 |
| C: I enjoyed doing these exercises. | 0.930 | 17 | 0.366 | 0.727 |
| | 1.020 | 15.881 | 0.323 | 0.727 |
| C: I would like to continue using Kanji glyph exercises to learn kanji. | 1.387 | 17 | 0.183 | 1.045 |
| | 1.573 | 13.512 | 0.139 | 1.045 |

## 11.14 Appendix N: Descriptive statistics for eye-tracking variables

Below are descriptive statistics for each of the eight variables in the eye-tracking fixation time data. The output from IBM SPSS Statistics 24 shows descriptive statistics, including the Mean, Standard Deviation, Skewness, and Kurtosis values for each of the variables.

*Results of data normality tests*

| Variables | | Statistic |
|---|---|---|
| hen_pre | Mean | 5.66 |
| | Std. Deviation | 2.56 |
| | Skewness | 0.88 |
| | Kurtosis | 1.56 |
| hen_post | Mean | 5.21 |
| | Std. Deviation | 2.05 |
| | Skewness | -0.17 |
| | Kurtosis | 1.97 |
| tsukuri_pre | Mean | 5.39 |
| | Std. Deviation | 3.22 |
| | Skewness | -0.13 |
| | Kurtosis | -1.56 |
| tsukuri_post | Mean | 9.31 |
| | Std. Deviation | 3.29 |
| | Skewness | -0.55 |
| | Kurtosis | -0.13 |
| kanmuri_pre | Mean | 2.68 |
| | Std. Deviation | 1.19 |
| | Skewness | 0.03 |
| | Kurtosis | -0.30 |
| kanmuri_post | Mean | 2.85 |
| | Std. Deviation | 1.26 |
| | Skewness | -0.51 |
| | Kurtosis | 0.11 |
| ashi_pre | Mean | 4.32 |
| | Std. Deviation | 3.10 |
| | Skewness | 0.82 |
| | Kurtosis | -0.20 |
| ashi_post | Mean | 3.80 |
| | Std. Deviation | 2.65 |
| | Skewness | 0.68 |
| | Kurtosis | -0.55 |