THE INFLUENCE OF BACKGROUND KNOWLEDGE ON STUDENTS' CONCEPTUALISATION AND DRAWING SKILLS IN FIRST YEAR LIFE SCIENCES

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ABSTRACT–Globally knowledge gaps have been identified in the Life Sciences classroom of first year students who join teacher education programs in tertiary institutions. These gaps are created by their different schooling backgrounds ranging from well-resourced schools with qualified Life Sciences educators to schools that are under-resourced and disadvantaged in various ways. This notion results in pedagogical challenges for lecturers who have to accommodate both groups through various strategies they incorporate into their teaching and learning programs. This qualitative study aims at identifying the knowledge gaps that exist due to the diverse schooling backgrounds of the first year Life Sciences students enrolled in the B.Ed. degree in the FET phase. As an evaluative study, a baseline assessment was given to first year Life Sciences students with the explicit purpose of identifying their prior competencies in the subject. Results from this assessment were analysed by means of Maton's Legitimation Code Theory (LCT) on semantic density. It was found that background knowledge influences conceptualisation and drawing skills of first year Life Sciences students. Consequently, some intervention strategies were proposed in this paper as ways of assisting the disadvantaged students in bridging and erasing the identified knowledge gaps.

Keywords: Life Sciences; background knowledge; conceptualization; drawing skills.

1. INTRODUCTION

It has been widely documented both nationally and internationally that undergraduate students encounter academic challenges especially during their first year at university. South Africa is not immune to this situation. Extant research alludes to high access and a relatively low throughput rate amongst undergraduate students in South African higher education institutions (HEIs) (Fisher and Scott, 2011; Bokana and Tewari, 2014). This situation is articulated more clearly in the CHE Report of the Task Team on Undergraduate Curriculum Structure (CHE, 2013). Consequently, Fisher and Scott (2011: 3) refer to the South African higher education system as "low participation - high attrition system". These inequalities are reflective of the apartheid legacy in terms of infrastructures at schools and the resultant effects on the acquisition of knowledge and skills (Booyse; le Roux, Seroto and Wolhuter, 2011).

At a macro level South African universities have been encouraged to position themselves as the centres of excellence and innovations and consequently admission criteria in the universities have been set at high levels. Yet HEIs have been charged politically to increase student access to everyone who meets entrance criteria. However the issue of the persistent distinctions between underprivileged and privileged backgrounds at an admissions level has not been thoroughly addressed. This notion is compounded by the fact that students enrolling at universities, coming from the disadvantaged backgrounds attend the same classes with other students who received a better quality secondary education. These differences in background knowledge pose a challenge to the lecturers. Hence baseline assessments are administered as a diagnostic tool before teaching and learning can take place. Furthermore lecturers have to design intervention strategies in an attempt to level the field for all students in order to address disparities in the Life Sciences classrooms.

Preparing and administering baseline assessments often put an additional load on lecturers as they cannot proceed without knowing what prior knowledge their students have.

The purpose of this study was to diagnose the impact of Life Sciences content knowledge gaps on the conceptualisation and drawing skills of first year Life Sciences students at the university where this evaluation study is conducted. The rationale of this study is that if these background knowledge gaps are left unattended, they could contribute to the high failure and attrition rates and consequently contribute to low throughput rates in the Life Sciences teacher education programs.

2. RESEARCH QUESTIONS
The following questions were raised and explored in this study:

1. What is the relationship between background knowledge, conceptualisation and drawing skills of the first year Life Sciences students?
2. What is the influence of the gaps in background knowledge on the conceptualisation and drawing skills of first year Life Sciences students?

3. THEORETICAL FRAMEWORK
This study is located within Bourdieu's theory of scientific capital, Maton's Legitimation Code Theory and Bhaskar's paradigm of critical realism. According to Bourdieu scientific capital is the disciplinary knowledge that endows Life Sciences students with peculiar skills that are controlled by the environment. The diverse backgrounds of the students that include the social field and the social space that they occupy, contribute to the environment that has an impact on the relationship between knowledge and skills of the students. This in turn influences the coping strategies that Life Sciences students apply in order to increase their scientific capital, i.e. their disciplinary knowledge. Life Sciences students because of their diverse backgrounds are differential agents of scientific capital in the disciplinary field. As agents they symbolically inform their acts of knowledge as well as recognition of their abilities by peers (Bourdieu, 2005). The implication is then that this occurs in a grading manner because of their experiences. Students then act within the constraints of the rules of the disciplinary field which in this case is Life Sciences.

The lecturer who works with this knowledge, i.e. of the differentiated scientific capital of students, functions within the HEI wider environment and assists with providing students with coping strategies. The environment further extends to institutional resources, policies, timetables and extended programs. This view resonates with that of Karl Maton (2012) that knowledge is relative, arbitrary and constructed by socially dominant interests, i.e. the environment

Students' action within the Life Sciences classroom can be best explained by Bhaskar's paradigm of critical realism which views the student as the "victim" in the centre of the lens that is searching for a strong causal explanation/mechanism of the performance of the student that is studied in detail. This theory further contends that an empirical or observable experience such as the drawing of the hypothetical insect is based on the conceptualisation of experience of the student. This conceptualisation is embedded within actual events that are generated by background knowledge, which in turn has been generated by real events such as the school experiences that shaped the student (Willcocks and Mingers, 2004). This study contends that by using these two approaches as proposed by Bourdieu and Bhaskar, a more in-depth study rather than a superficial broad observation of the pass rate of all the first year Life Sciences students was possible. Bourdieu (1994a:170) as cited in Maton (2012: 51) accurately captures this social nature of knowledge by means of the term "habitus" which he defines "as a property of social agents (whether individuals, groups or institutions) that comprises "a structured and structuring structure". It is "structured" by one's past and present circumstances, such as family upbringing and educational experiences. It is "structuring" that shapes one's practices." Furthermore the relationship between habitus or disposition of the Life Sciences student and the scientific capital of the Life Sciences discipline is

tantamount to practice in this case knowledge practice. Knowledge practices therefore are influenced by habitus and the prevailing circumstances and environment. Habitus therefore relates to our way of being, i.e. the ontology which is actively and continuously evolving (Maton, 2012).

One way in which this study attempted to make sense of students' performance and to investigate their knowledge practices in first year Life Sciences, was by using the principles of the Legitimation Code Theory (LCT) of Maton (2014). LCT is a sociological framework and a multi-dimensional toolkit that uses legitimation codes. One of the dimensions of the LCT is semantics which relates to social structure. The semantic structure or social field of a knowledge practice determines its strength. Semantic codes reveal knowledge practices and for the purpose of this study the focus will be on semantic density which is one of the semantic codes that resort under semantic structure (Maton, 2014). Semantic density (SD) refers to the degree of condensation of meaning in practices and may be stronger (+) or weaker (-) along a continuum of strengths that ranges from more condensed meaning (SD+) to less condensed meaning (SD-). Abstract scientific terms or concepts have a broad range of meanings and would typically be regarded to have a high position on the semantic density scale, i.e. SD+. However as these concepts were explained to the students by unpacking them, the semantic density of those concepts were weakened. Knowledge was thus transformed as the students in turn applied the concepts by repacking them in order to draw the hypothetical insect and thereby increasing or strengthening the semantic density of these concepts (Maton, 2014).

4. LITERATURE REVIEW

Life Sciences as one of the science subjects is seen as challenging by undergraduate students coming into the Bachelors of Education programs in most universities in South Africa. This has been the same case in the university of technology where this study is conducted. A reason for this could be the change in habitus (as defined by Bourdieu) which manifests itself as knowledge gaps. These gaps exist because of differences in Life Sciences content taught at secondary school level and at first year university level.

Another challenge is the conceptualisation of key terms or concepts that are fundamental to the subject. Meyer and Land (2003) referred to these key concepts as threshold concepts which they define as "core concepts that once understood, transform perception of a given subject". Meyer and Land (2003) also coin-phrased the term "troublesome knowledge", as that which prevents students from applying their knowledge to new situations. This may result in tasks being performed mechanically but without the student having a solid understanding of the concepts that form the basis of the task at hand. In this case, threshold concepts have become troublesome knowledge (Meyer and Land, 2003) because students are driven by content and therefore struggle to relate theory to practice (Botha and Reddy, 2011).

The differences in background knowledge can be explained by Goldberg and Thompson-Schill (2009) as the acquisition of more knowledge and the mastering of the biological knowledge domain that happens in a piecemeal fashion. They further contend that early biases in the conceptualisation of biological knowledge stem from developmental roots that are not overwritten by the school experiences of students.). According to Bourdieu (1994a) as cited in Maton (2012) knowledge which is an unobservable structure addresses the hidden or imagined properties that manifest themselves separately or combined as events or symptoms on the surface. This perspective allows a researcher to distinguish between the event which is a drawing of the hypothetical insect shaped by the structure which in this case is the conceptualisation or the absence thereof of the first year Life Sciences student.

5. METHODOLOGY

Program evaluation was used as a methodology to inform the collection and interpretation of the data collected for the study (Babbie and Mouton, 2007). This method gave the researchers access to the conceptual understanding of the first year Life Sciences students. A baseline assessment (appendix 1 and 2) was given to first year students to identify whether they could use Life Sciences concepts in order to draw a hypothetical insect.

A sample size of 15 first year Life Sciences students out of a total of 110 was purposively selected for this study. 47% of them have performed well in drawing the hypothetical insect while the other 53% achieved low scores. Initially, each concept was categorized as familiar and non-familiar to the students as most of the Life Sciences concepts in the task were viewed by the researchers as almost common knowledge that is assumed to be part of the background knowledge of first year students. Biological concepts as well as their definitions were given followed by detailed instructions of how the assessment was to be done. The data obtained from the study is presented in a form of a table and was analysed and interpreted by means of the LCT using semantic density according to Maton's semantic wave theory.

The baseline assessment has been administered to different cohorts of first year Life Sciences student for the last five years and has yielded the same results. Therefore it has been seen as a reliable tool for research purposes (Pietersen and Maree, 2013). The findings of this study have given a miniature picture of the general challenges faced by different HEIs in South Africa and therefore strengthen the validity of this evaluation study (Bertram and Christiansen, 2014).

6. RESULTS

The baseline assessment scores of the respondents are presented in table 1 below. The task and its marking guide (Appendices 1 and 2) are presented in this paper as evidence of which terminology and concepts were expected to be prior knowledge of a first year student who has achieved more than 55% in matric Life Sciences. The assumption is that first year pre-service Life Sciences teachers would be able to comfortably use terminology, apply concepts and follow instructions to draw a hypothetical insect.

Table 1. Comparison of baseline assessment scores of first year Life Sciences pre-service teachers (+ means the meaning is more condensed; - means that the meaning is less condensed)

Student	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Baseline assessment score (%)	97	97	97	97	100	97	97	93	53	53	47	50	50	43	20
Semantic density (SD+ or SD-)	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-

Results showed the following:

- it is not a guarantee that all the first year Life Sciences students have the scientific capital as the knowers of Life Sciences or the agents in the field of Life Sciences.
- the threshold concepts can become troublesome knowledge, i.e. what was assumed to be familiar concepts which form part of their background knowledge in its absence seemingly created problems for those students who achieved low scores
- the change in habitus (i.e. the difference in school and university Life Sciences content) and the social field (i.e. the differences in the school and university environments) influence the knowledge practice as demonstrated by the conceptualisation and the drawing skills of the first year Life Sciences students.

- the high level (47 % of the sample) of lower semantic density (SD-) demonstrates that the orientation to meaning or knowledge transformation is different to that of their counterparts (53% of the sample) who achieved higher levels of semantic density (SD+).

7. DISCUSSION

A possible explanation for the results obtained from this study could be that direct instruction has influenced the scientific capital (i.e. the disciplinary knowledge practice) of especially the poor performers. It seems that conceptualisation was compromised resulting in weak semantic density of most of the concepts they had to apply when they had to draw a hypothetical insect. The semantic density was therefore weakened as the students struggled to repack concepts in order to construct the drawing. Another assumption can be that students relied on memorization of facts and that at secondary school level they might have received their body of Life Sciences knowledge in a non-interactive and fragmented way. As agents of scientific capital students could not make the necessary links due to their perceived misconceptions and therefore students' drawing skills based on Life Sciences concepts are compromised (Syh-Jong, 2007).

It is therefore necessary to continually assess different means of understanding of who a first year Life Sciences student is who enrolls in the teacher training program. One aspect that needs to be taken further is the issue of where these students are coming from. In as much as South Africa has two decades of democracy, there are still gaps lingering in the schooling of different societies within the same nation. Hence the environment with adequate or inadequate resources have a direct bearing on the scientific capital of the student who has to move from one habitus (schooling environment) to another (the Institution of Higher Education) and who are faced with the challenge of adapting to a new environment. Whilst not ignoring all the other skills that are important in the making of a teacher, it must be acknowledged that knowledge of the subject- specific content is the primary task of being a Life Sciences teacher (Fernandez, 2012).

8. CONCLUSIONS AND RECOMMENDATIONS

It has been evident from this study that there are gaps in the background knowledge that have an influence on the conceptualisation and drawing skills of first year Life Sciences students. In order to minimize and erase these gaps there could be intervention programs to level the field for all first year students in Life Sciences. Different scaffolding methods related to the context of these respondents could be introduced before the challenge of high attrition rates and low throughput rates are addressed. The inclusion of extended degree programs need to be explored to try to address the knowledge gaps in order to retain students within the teacher education and training programs.

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APPENDIX 1

ASSIGNMENT 1   Reading, following of instructions and drawing skills using a hypothetical insect (*Insect singularis*)

The aim of this exercise (Brett W.J., 1989, JSTOR: The American Biology Teacher,vol.51 (1): 43 -45) is to make you as a future educator aware of the importance of the following skills that form an important part of teaching and learning in Life Sciences and Natural Sciences.

- proper reading of study material

- following of instructions

- practising of good drawing and labeling habits

- mastering of biological terms

Table 1 (Vocabulary) consist of a list of terms and definitions that you must use in this exercise that requires you to draw a hypothetical insect.

TABLE 1

abdomen	The body part posterior to the thorax, behind the diaphragm in mammals
antennae	A sensory appendage/organ on arthropods that projects from the head: it contains chemical receptors
anterior	The front part/forward-moving/head of an animal
anus	Posterior opening of the digestive tract
apex	The end or point of a structure
appendage	A movable projecting part on an animal body having an active function
axis	Central or principal line bisecting a body, form, or the like, and in relation to which symmetry is determined
caption	A heading or a title; legend for a figure or a graph, it is placed below the figure in scientific literature
cephalic	Pertaining to or toward head
distal	Away from the point of attachment
dorsal	Toward or pertaining to the back or upper surface
equal	Evenly proportioned or in the same quantity
homologous	Of like source in structure and embryonic development of primitive origin

TABLE 1 (continued)

label	A word or phrase descriptive of a structure
labial	Pertaining to lips
lateral	Of or pertaining to side
lingual	Pertaining to the tongue
longitudinal	Pertaining to or along the long axis of the body
median	Situated in or pertaining to the middle
metamere	Any one of a series of homologous parts in the body
neophyte	A beginner
parallel	Extending in the same direction equal distances from each other
perpendicular	Meeting a given line or surface at right angles
posterior	The hind/rear part or toward the tail end; away from the head
prothorax	The most anterior of the three segments of the thorax
proximal	Toward or nearer to the place of attachment
segment	A part that is marked off or separated from others
seta	A bristle or slender stiff bristle-like structure
spiracle	In insects an external opening to the tracheal or respiratory system
terminal	Situated at or forming the end or extremity of something
thorax	The division of an animal next to or behind the head; in insects it bears the legs and the wings
ventral	Toward the lower side or belly; away from the back

If you understand the terms and follow the instructions closely your correct drawing will be evidence that you have completed this exercise successfully.

MATERIALS:

You will need the following items in order to successfully complete this exercise:
        pencil, sharpener, eraser, ruler, protractor, compass, scissors
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INSTRUCTIONS:

- In constructing your drawing of *Insect singularis*, use only straight ruled lines and circles drawn with the metric template and ruler.

- Circle dimensions refer to the required diameter.

- Use the protractor to correctly determine angular measurements.

- Locate a point midway between the short sides of the paper and draw through this point a line 120mm long and perpendicular to the long side of the page. Allow for lateral margins of equal width at either end of this line.

- Draw a second line parallel to the first line and located 50mm from it.

- Position the paper so that the line closest to the edge of the paper is away from you.

- The anterior end of the insect will be directed toward the left hand margin of the paper and the dorsal surface will be represented by the line closest to the edge of the page.

- At the anterior end of the insect draw a line connecting the dorsal and ventral surfaces.

- At the posterior end draw a line perpendicular to the dorsal surface and extending toward the ventral surface. Make this line 36mm long.

- Also at the posterior end draw a second shorter line perpendicular to the ventral surface and extending toward the dorsal surface. Make this line 10mm long.

- The 4mm gap between the ends of the last two lines drawn, represents the anal opening.

- Draw a perpendicular line from the dorsal to the ventral surface and exactly 31mm from the anterior end; this line marks the posterior border of the insect's cephalic segment.

- Construct a similar line 50mm from the posterior end of the insect; this line marks the anterior border of the abdomen and the posterior border of the thorax. You have constructed the major divisions of the body of your insect.

- Draw lines perpendicular to the dorsal surface positioned so that the thorax is divided into three metameres of equal area.

- Sketch three appendages, each consisting of three segments perpendicular and ventral to the ventral surface of the thorax. Make the proximal segment of each appendage a square with sides 9mm long and centered on the ventral surface of a thoracic segment. Make the median segment 7mm wide and 10mm long and center it on the distal end of the proximal segment. The distal segment should be 5mm wide and 15mm long and be centered on the distal surface of the median segment.

- Represent terminal setae by drawing a single 3mm long pencil line perpendicular and ventral to and from the center of the distal end of each appendage.

- Place wings on your insect by extending a 40mm line perpendicular and dorsal to the dorsal surface at the anterior border of the prothoracic segment. Now extend a 40mm line dorsally and posteriorly at a 45-degree angle from the posterior border of the prothorax segment. Connect the distal end of this line with the distal end of the other wing line.

- Divide the abdomen into five metameres of equal area by drawing four lines perpendicular to the dorsal surface and extending to the ventral surface.

- Divide the abdominal segments into dorsal and ventral portions by a median longitudinal line.

- To represent the opening of the spiracle, draw a circle 2mm in diameter in each abdominal segment. Locate the spiracle halfway along the length of the segment and with its dorsal border just touching the median longitudinal line.

- You will now concentrate on providing structures for the insect's head. Draw a 2mm thick antenna with its base at the angle of the anterior and dorsal surfaces of the head. Extend the antenna 30mm at a 45-degree angle so that it projects anteriorly and dorsally to the head. Separate the antenna into five segments of equal length and extend the antenna by adding a circle 3mm in diameter to the distal segment so that the circumference of the circle touches the midpoint of the apex.

- Construct mouth parts by drawing two labial and one lingual structures. One labial structure 3mm wide and 10mm long should extend perpendicularly from the anterior surface of the head with its ventral border 5mm from the ventral border of the head. A second labial structure, of the same dimensions, should extend perpendicularly from the ventral surface of the head with its anterior border 5mm from the anterior border of the head. Connect the ends of the lines, which represent the upper and lower borders of each lip, with short perpendiculars. The lingual structure is to be 2mm thick and 8mm long and extend at a 45-degree angle from the head with its base situated equally between the two labial structures. Connect the ends of the lines which represent the upper and lower borders of the tongue with a short perpendicular line.

- Place an eye on the head segment by drawing an 8mm diameter circle whose center is 15mm from both the dorsal and anterior surfaces of the head.

- Although you and I know your drawing represents an insect and we can recognize its various parts and structures, it might be good to label it so neophytes are able to recognize it for what it is.

- Label structures by extending 5mm lines which run parallel to the longitudinal axis of your insect; if possible, do not have any of the lines or labels cross body structures.

- Use lower case printed letters for your labels.

- Place labels on the following structures: antenna, anus, dorsal lip, leg, tongue, ventral lip, and wing.

- Place a caption 25mm below the drawing. Use the following caption: **Figure 1. Hypothetical insect produced by (your names) on the basis of provided terms and directions**. The first letter of the caption should be in upper case and 3cm from the left hand margin of the paper. The caption should extend equal distances from both the left-hand and the right hand margin. If it is necessary to have a second line of print in the caption, start it at the same distance from the margin as the first line.

- Please submit your drawing to be evaluated for accuracy.

MARKING GUIDE

ASSIGNMENT   Reading, Following of instructions and drawing skills using a hypothetical insect (*Insect singularis*)

Neatness ✓ (1)
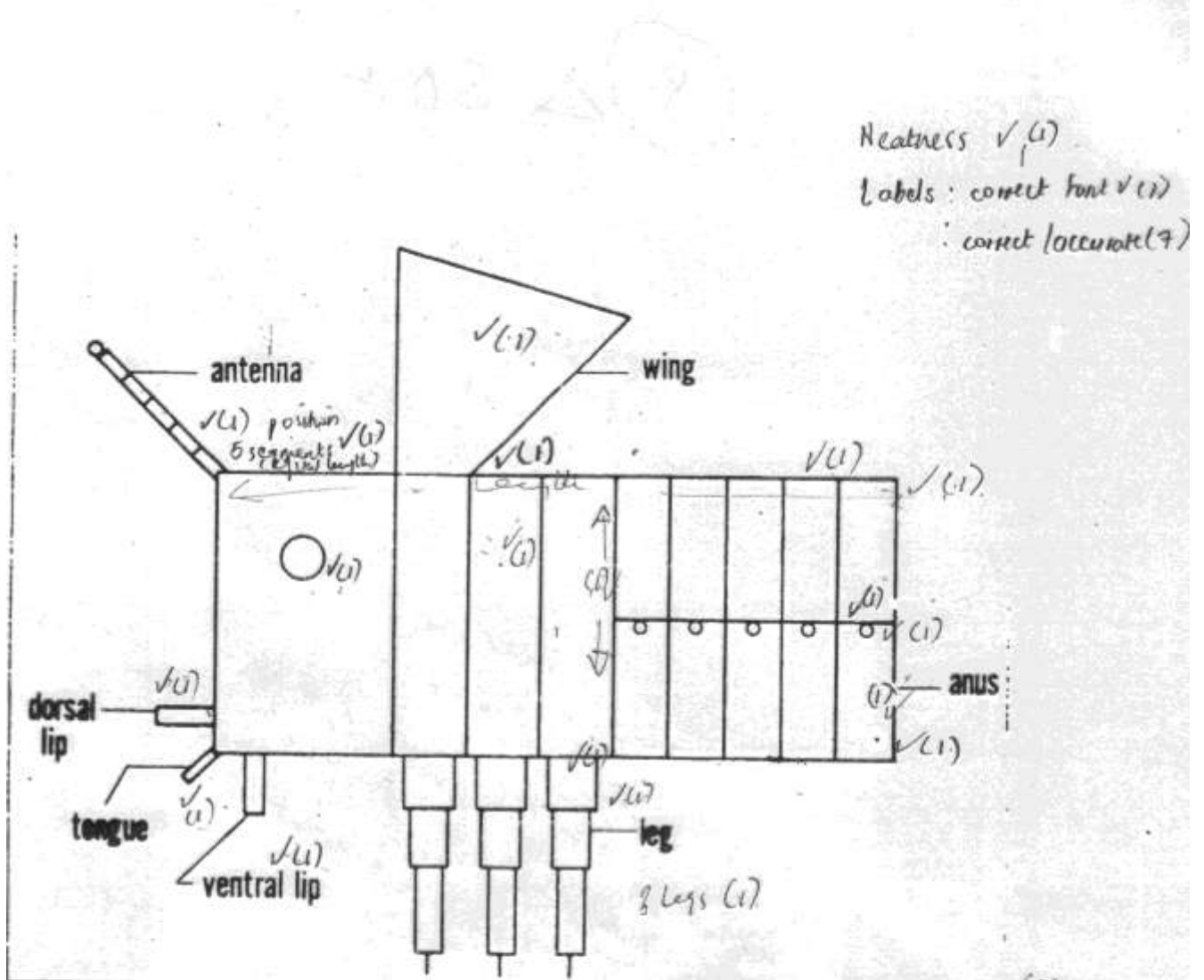Labels : correct font ✓ (1)
: correct / accurate (7)

Figure 1.   Heading done according to instructions - same distance from both margins (L&R)
Correct heading:
Hypothetical insect produced by . . and . . . on the basis of provided terms and directions ✓ (1)

antenna ✓ (1) position ✓ (1)
6 segments ✓ (1) equal length
wing ✓ (1)
dorsal lip ✓ (1)
tongue ✓ (1)
ventral lip ✓ (1)
leg ✓ (1)
3 legs (1)
anus
✓ (1)