1. Implement the Continuous Bag of Words (CBOW) Model. Stages can be:
   a. Data preparation
   b. Generate training data
   c. Train model
   d. Output

In [1]:
```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense,\
        Embedding, Lambda
from tensorflow.keras.preprocessing.text import Tokenizer
import numpy as np
import matplotlib.pyplot as plt
from sklearn.decomposition import PCA
import re
```

```
2023-11-05 10:46:30.013620: I tensorflow/core/platform/cpu_feature_guard.c
c:182] This TensorFlow binary is optimized to use available CPU instructio
ns in performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebui
ld TensorFlow with the appropriate compiler flags.
```

a. Data preparation

In [2]:
```
data = """We are about to study the idea of a computational process.
Computational processes are abstract beings that inhabit computers.
As they evolve, processes manipulate other abstract things called data.
The evolution of a process is directed by a pattern of rules
called a program. People create programs to direct processes. In effect,
we conjure the spirits of the computer with our spells."""
```

In [3]:
```
# for importing data from txt file
# with open("data.txt", "r", encoding="utf-8") as file:
#     data = file.read()
```

In [4]:
```
sentences = data.split(".")
```

In [5]:
```
sentences
```

Out[5]:
```
['We are about to study the idea of a computational process',
 '\nComputational processes are abstract beings that inhabit computers',
 '\nAs they evolve, processes manipulate other abstract things called dat
a',
 '\nThe evolution of a process is directed by a pattern of rules\ncalled a
program',
 ' People create programs to direct processes',
 ' In effect,\nwe conjure the spirits of the computer with our spells',
 '']
```

In [6]:
```
#Clean Data
clean_sentences = []
for sentence in sentences:
    # skip empty string
```

```
    if sentence == "":
        continue;
    # remove special characters
    sentence = re.sub('[^A-Za-z0-9]+', ' ', sentence)
    # remove 1 letter words
    sentence = re.sub(r'(?:^| )\w(?:$| )', ' ', sentence).strip()
    # lower all characters
    sentence = sentence.lower()
    clean_sentences.append(sentence)
```

In [7]:
```
clean_sentences
```

Out[7]:
```
['we are about to study the idea of computational process',
 'computational processes are abstract beings that inhabit computers',
 'as they evolve processes manipulate other abstract things called data',
 'the evolution of process is directed by pattern of rules called progra
m',
 'people create programs to direct processes',
 'in effect we conjure the spirits of the computer with our spells']
```

In [8]:
```
# Define the corpus
corpus = clean_sentences
```

In [9]:
```
# Convert the corpus to a sequence of integers
tokenizer = Tokenizer()
tokenizer.fit_on_texts(corpus)
sequences = tokenizer.texts_to_sequences(corpus)
print("After converting our words in the corpus \
into vector of integers:")
print(sequences)
```

```
After converting our words in the corpus into vector of integers:
[[4, 5, 11, 6, 12, 1, 13, 2, 7, 8], [7, 3, 5, 9, 14, 15, 16, 17], [18, 19,
20, 3, 21, 22, 9, 23, 10, 24], [1, 25, 2, 8, 26, 27, 28, 29, 2, 30, 10, 3
1], [32, 33, 34, 6, 35, 3], [36, 37, 4, 38, 1, 39, 2, 1, 40, 41, 42, 43]]
```

In [10]:
```
# creating dictionary for word to index and index to word
index_to_word_map = {}
word_to_index_map = {}
for index_1, sequence in enumerate(sequences):
    print(sequence)
    words_in_sentence = clean_sentences[index_1].split()
    print(words_in_sentence)
    for index_2, value in enumerate(sequence):
        index_to_word_map[value] = words_in_sentence[index_2]
        word_to_index_map[words_in_sentence[index_2]] = value
```

```
[4, 5, 11, 6, 12, 1, 13, 2, 7, 8]
['we', 'are', 'about', 'to', 'study', 'the', 'idea', 'of', 'computationa
l', 'process']
[7, 3, 5, 9, 14, 15, 16, 17]
['computational', 'processes', 'are', 'abstract', 'beings', 'that', 'inhab
it', 'computers']
[18, 19, 20, 3, 21, 22, 9, 23, 10, 24]
['as', 'they', 'evolve', 'processes', 'manipulate', 'other', 'abstract',
'things', 'called', 'data']
[1, 25, 2, 8, 26, 27, 28, 29, 2, 30, 10, 31]
['the', 'evolution', 'of', 'process', 'is', 'directed', 'by', 'pattern',
'of', 'rules', 'called', 'program']
[32, 33, 34, 6, 35, 3]
['people', 'create', 'programs', 'to', 'direct', 'processes']
[36, 37, 4, 38, 1, 39, 2, 1, 40, 41, 42, 43]
['in', 'effect', 'we', 'conjure', 'the', 'spirits', 'of', 'the', 'compute
r', 'with', 'our', 'spells']
```

In [11]:
```
print(index_to_word_map)
print("\n")
print(word_to_index_map)
```

```
{4: 'we', 5: 'are', 11: 'about', 6: 'to', 12: 'study', 1: 'the', 13: 'ide
a', 2: 'of', 7: 'computational', 8: 'process', 3: 'processes', 9: 'abstrac
t', 14: 'beings', 15: 'that', 16: 'inhabit', 17: 'computers', 18: 'as', 1
9: 'they', 20: 'evolve', 21: 'manipulate', 22: 'other', 23: 'things', 10:
'called', 24: 'data', 25: 'evolution', 26: 'is', 27: 'directed', 28: 'by',
29: 'pattern', 30: 'rules', 31: 'program', 32: 'people', 33: 'create', 34:
'programs', 35: 'direct', 36: 'in', 37: 'effect', 38: 'conjure', 39: 'spir
its', 40: 'computer', 41: 'with', 42: 'our', 43: 'spells'}


{'we': 4, 'are': 5, 'about': 11, 'to': 6, 'study': 12, 'the': 1, 'idea': 1
3, 'of': 2, 'computational': 7, 'process': 8, 'processes': 3, 'abstract':
9, 'beings': 14, 'that': 15, 'inhabit': 16, 'computers': 17, 'as': 18, 'th
ey': 19, 'evolve': 20, 'manipulate': 21, 'other': 22, 'things': 23, 'calle
d': 10, 'data': 24, 'evolution': 25, 'is': 26, 'directed': 27, 'by': 28,
'pattern': 29, 'rules': 30, 'program': 31, 'people': 32, 'create': 33, 'pr
ograms': 34, 'direct': 35, 'in': 36, 'effect': 37, 'conjure': 38, 'spirit
s': 39, 'computer': 40, 'with': 41, 'our': 42, 'spells': 43}
```

b. Generate training data

In [12]:
```
# Define the parameters
vocab_size = len(tokenizer.word_index) + 1
embedding_size = 10
window_size = 2

# Generate the context-target pairs
contexts = []
targets = []
for sequence in sequences:
        for i in range(window_size, len(sequence) - window_size):
                context = sequence[i - window_size:i] + sequence[i + 1:i +
                target = sequence[i]
                contexts.append(context)
                targets.append(target)
```

In [13]:
```
# sample of training data
for i in range(5):
    words = []
    target = index_to_word_map.get(targets[i])
    for j in contexts[i]:
        words.append(index_to_word_map.get(j))
    print(words, "=>", target)
```

```
['we', 'are', 'to', 'study'] => about
['are', 'about', 'study', 'the'] => to
['about', 'to', 'the', 'idea'] => study
['to', 'study', 'idea', 'of'] => the
['study', 'the', 'of', 'computational'] => idea
```

In [14]:
```
# Convert the contexts and targets to numpy arrays
X = np.array(contexts)
Y = np.array(targets)
```

c. Train model

In [15]:
```
# Define the CBOW model
model = Sequential()
model.add(Embedding(input_dim=vocab_size, output_dim=embedding_size, input
model.add(Lambda(lambda x: tf.reduce_mean(x, axis=1)))
model.add(Dense(256, activation='relu'))
model.add(Dense(512, activation='relu'))
model.add(Dense(units=vocab_size, activation='softmax'))

# Compile the model
model.compile(loss='sparse_categorical_crossentropy', optimizer='adam', me

# Train the model
model.fit(X, Y, epochs=200, verbose=1)
```

```
Epoch 1/200
2/2 [==============================] - 0s 8ms/step - loss: 3.7840 - accura
cy: 0.0294
Epoch 2/200
2/2 [==============================] - 0s 6ms/step - loss: 3.7747 - accura
cy: 0.1765
Epoch 3/200
2/2 [==============================] - 0s 6ms/step - loss: 3.7670 - accura
cy: 0.1176
Epoch 4/200
2/2 [==============================] - 0s 7ms/step - loss: 3.7590 - accura
cy: 0.1176
Epoch 5/200
2/2 [==============================] - 0s 6ms/step - loss: 3.7490 - accura
cy: 0.1176
Epoch 6/200
2/2 [==============================] - 0s 6ms/step - loss: 3.7379 - accura
cy: 0.1176
Epoch 7/200
2/2 [==============================] - 0s 7ms/step - loss: 3.7251 - accura
cy: 0.1176
Epoch 8/200
2/2 [==============================] - 0s 6ms/step - loss: 3.7099 - accura
cy: 0.1176
Epoch 9/200
2/2 [==============================] - 0s 7ms/step - loss: 3.6919 - accura
cy: 0.1176
Epoch 10/200
2/2 [==============================] - 0s 5ms/step - loss: 3.6711 - accura
cy: 0.1471
Epoch 11/200
2/2 [==============================] - 0s 6ms/step - loss: 3.6471 - accura
cy: 0.1471
Epoch 12/200
2/2 [==============================] - 0s 5ms/step - loss: 3.6184 - accura
cy: 0.1176
Epoch 13/200
2/2 [==============================] - 0s 6ms/step - loss: 3.5851 - accura
cy: 0.1176
Epoch 14/200
2/2 [==============================] - 0s 5ms/step - loss: 3.5477 - accura
cy: 0.1176
Epoch 15/200
2/2 [==============================] - 0s 5ms/step - loss: 3.5061 - accura
cy: 0.1176
Epoch 16/200
2/2 [==============================] - 0s 6ms/step - loss: 3.4633 - accura
cy: 0.1176
Epoch 17/200
2/2 [==============================] - 0s 8ms/step - loss: 3.4173 - accura
cy: 0.1176
Epoch 18/200
2/2 [==============================] - 0s 6ms/step - loss: 3.3707 - accura
cy: 0.1176
Epoch 19/200
2/2 [==============================] - 0s 5ms/step - loss: 3.3228 - accura
cy: 0.1176
Epoch 20/200
2/2 [==============================] - 0s 5ms/step - loss: 3.2718 - accura
```

```
cy: 0.1176
Epoch 21/200
2/2 [==============================] - 0s 6ms/step - loss: 3.2240 - accura
cy: 0.1176
Epoch 22/200
2/2 [==============================] - 0s 5ms/step - loss: 3.1789 - accura
cy: 0.1176
Epoch 23/200
2/2 [==============================] - 0s 5ms/step - loss: 3.1368 - accura
cy: 0.1471
Epoch 24/200
2/2 [==============================] - 0s 4ms/step - loss: 3.1041 - accura
cy: 0.1471
Epoch 25/200
2/2 [==============================] - 0s 5ms/step - loss: 3.0692 - accura
cy: 0.1471
Epoch 26/200
2/2 [==============================] - 0s 5ms/step - loss: 3.0417 - accura
cy: 0.1471
Epoch 27/200
2/2 [==============================] - 0s 6ms/step - loss: 3.0187 - accura
cy: 0.1471
Epoch 28/200
2/2 [==============================] - 0s 5ms/step - loss: 3.0006 - accura
cy: 0.1176
Epoch 29/200
2/2 [==============================] - 0s 6ms/step - loss: 2.9701 - accura
cy: 0.1176
Epoch 30/200
2/2 [==============================] - 0s 5ms/step - loss: 2.9323 - accura
cy: 0.1176
Epoch 31/200
2/2 [==============================] - 0s 5ms/step - loss: 2.8934 - accura
cy: 0.1176
Epoch 32/200
2/2 [==============================] - 0s 5ms/step - loss: 2.8603 - accura
cy: 0.1471
Epoch 33/200
2/2 [==============================] - 0s 6ms/step - loss: 2.8345 - accura
cy: 0.1765
Epoch 34/200
2/2 [==============================] - 0s 5ms/step - loss: 2.8075 - accura
cy: 0.2353
Epoch 35/200
2/2 [==============================] - 0s 5ms/step - loss: 2.7839 - accura
cy: 0.2647
Epoch 36/200
2/2 [==============================] - 0s 6ms/step - loss: 2.7592 - accura
cy: 0.2647
Epoch 37/200
2/2 [==============================] - 0s 5ms/step - loss: 2.7336 - accura
cy: 0.2647
Epoch 38/200
2/2 [==============================] - 0s 5ms/step - loss: 2.7042 - accura
cy: 0.2353
Epoch 39/200
2/2 [==============================] - 0s 6ms/step - loss: 2.6726 - accura
cy: 0.2353
Epoch 40/200
```

```
2/2 [==============================] - 0s 5ms/step - loss: 2.6350 - accura
cy: 0.2647
Epoch 41/200
2/2 [==============================] - 0s 5ms/step - loss: 2.5918 - accura
cy: 0.2353
Epoch 42/200
2/2 [==============================] - 0s 6ms/step - loss: 2.5551 - accura
cy: 0.2647
Epoch 43/200
2/2 [==============================] - 0s 5ms/step - loss: 2.5199 - accura
cy: 0.2647
Epoch 44/200
2/2 [==============================] - 0s 5ms/step - loss: 2.4888 - accura
cy: 0.2353
Epoch 45/200
2/2 [==============================] - 0s 5ms/step - loss: 2.4622 - accura
cy: 0.2353
Epoch 46/200
2/2 [==============================] - 0s 5ms/step - loss: 2.4347 - accura
cy: 0.2647
Epoch 47/200
2/2 [==============================] - 0s 5ms/step - loss: 2.4077 - accura
cy: 0.2941
Epoch 48/200
2/2 [==============================] - 0s 4ms/step - loss: 2.3822 - accura
cy: 0.3235
Epoch 49/200
2/2 [==============================] - 0s 5ms/step - loss: 2.3580 - accura
cy: 0.3235
Epoch 50/200
2/2 [==============================] - 0s 5ms/step - loss: 2.3299 - accura
cy: 0.2941
Epoch 51/200
2/2 [==============================] - 0s 6ms/step - loss: 2.3047 - accura
cy: 0.3235
Epoch 52/200
2/2 [==============================] - 0s 5ms/step - loss: 2.2747 - accura
cy: 0.3235
Epoch 53/200
2/2 [==============================] - 0s 5ms/step - loss: 2.2469 - accura
cy: 0.3235
Epoch 54/200
2/2 [==============================] - 0s 5ms/step - loss: 2.2179 - accura
cy: 0.3235
Epoch 55/200
2/2 [==============================] - 0s 4ms/step - loss: 2.1988 - accura
cy: 0.3529
Epoch 56/200
2/2 [==============================] - 0s 4ms/step - loss: 2.1861 - accura
cy: 0.3824
Epoch 57/200
2/2 [==============================] - 0s 5ms/step - loss: 2.1612 - accura
cy: 0.3824
Epoch 58/200
2/2 [==============================] - 0s 5ms/step - loss: 2.1344 - accura
cy: 0.3824
Epoch 59/200
2/2 [==============================] - 0s 6ms/step - loss: 2.0989 - accura
cy: 0.3824
```

```
Epoch 60/200
2/2 [==============================] - 0s 6ms/step - loss: 2.0641 - accura
cy: 0.3824
Epoch 61/200
2/2 [==============================] - 0s 6ms/step - loss: 2.0409 - accura
cy: 0.3824
Epoch 62/200
2/2 [==============================] - 0s 4ms/step - loss: 2.0243 - accura
cy: 0.4118
Epoch 63/200
2/2 [==============================] - 0s 5ms/step - loss: 2.0030 - accura
cy: 0.4118
Epoch 64/200
2/2 [==============================] - 0s 5ms/step - loss: 1.9711 - accura
cy: 0.4118
Epoch 65/200
2/2 [==============================] - 0s 5ms/step - loss: 1.9392 - accura
cy: 0.4118
Epoch 66/200
2/2 [==============================] - 0s 6ms/step - loss: 1.9070 - accura
cy: 0.4412
Epoch 67/200
2/2 [==============================] - 0s 5ms/step - loss: 1.8823 - accura
cy: 0.4412
Epoch 68/200
2/2 [==============================] - 0s 4ms/step - loss: 1.8635 - accura
cy: 0.4118
Epoch 69/200
2/2 [==============================] - 0s 5ms/step - loss: 1.8362 - accura
cy: 0.4118
Epoch 70/200
2/2 [==============================] - 0s 4ms/step - loss: 1.8038 - accura
cy: 0.5000
Epoch 71/200
2/2 [==============================] - 0s 4ms/step - loss: 1.7620 - accura
cy: 0.5000
Epoch 72/200
2/2 [==============================] - 0s 4ms/step - loss: 1.7261 - accura
cy: 0.4412
Epoch 73/200
2/2 [==============================] - 0s 5ms/step - loss: 1.6860 - accura
cy: 0.5000
Epoch 74/200
2/2 [==============================] - 0s 4ms/step - loss: 1.6592 - accura
cy: 0.5000
Epoch 75/200
2/2 [==============================] - 0s 4ms/step - loss: 1.6409 - accura
cy: 0.5294
Epoch 76/200
2/2 [==============================] - 0s 4ms/step - loss: 1.6168 - accura
cy: 0.5000
Epoch 77/200
2/2 [==============================] - 0s 4ms/step - loss: 1.5851 - accura
cy: 0.4706
Epoch 78/200
2/2 [==============================] - 0s 5ms/step - loss: 1.5540 - accura
cy: 0.5294
Epoch 79/200
2/2 [==============================] - 0s 4ms/step - loss: 1.5164 - accura
```

```
cy: 0.5294
Epoch 80/200
2/2 [==============================] - 0s 4ms/step - loss: 1.4713 - accura
cy: 0.5588
Epoch 81/200
2/2 [==============================] - 0s 4ms/step - loss: 1.4381 - accura
cy: 0.5588
Epoch 82/200
2/2 [==============================] - 0s 5ms/step - loss: 1.4111 - accura
cy: 0.5588
Epoch 83/200
2/2 [==============================] - 0s 5ms/step - loss: 1.3882 - accura
cy: 0.6471
Epoch 84/200
2/2 [==============================] - 0s 4ms/step - loss: 1.3698 - accura
cy: 0.6471
Epoch 85/200
2/2 [==============================] - 0s 4ms/step - loss: 1.3491 - accura
cy: 0.6471
Epoch 86/200
2/2 [==============================] - 0s 4ms/step - loss: 1.3175 - accura
cy: 0.6765
Epoch 87/200
2/2 [==============================] - 0s 4ms/step - loss: 1.2793 - accura
cy: 0.6471
Epoch 88/200
2/2 [==============================] - 0s 4ms/step - loss: 1.2423 - accura
cy: 0.6176
Epoch 89/200
2/2 [==============================] - 0s 5ms/step - loss: 1.2128 - accura
cy: 0.6765
Epoch 90/200
2/2 [==============================] - 0s 4ms/step - loss: 1.1877 - accura
cy: 0.6471
Epoch 91/200
2/2 [==============================] - 0s 5ms/step - loss: 1.1603 - accura
cy: 0.6765
Epoch 92/200
2/2 [==============================] - 0s 6ms/step - loss: 1.1398 - accura
cy: 0.7353
Epoch 93/200
2/2 [==============================] - 0s 4ms/step - loss: 1.1215 - accura
cy: 0.6471
Epoch 94/200
2/2 [==============================] - 0s 4ms/step - loss: 1.1028 - accura
cy: 0.6471
Epoch 95/200
2/2 [==============================] - 0s 4ms/step - loss: 1.0773 - accura
cy: 0.7059
Epoch 96/200
2/2 [==============================] - 0s 4ms/step - loss: 1.0495 - accura
cy: 0.7353
Epoch 97/200
2/2 [==============================] - 0s 5ms/step - loss: 1.0164 - accura
cy: 0.7647
Epoch 98/200
2/2 [==============================] - 0s 4ms/step - loss: 0.9861 - accura
cy: 0.7647
Epoch 99/200
```

```
2/2 [==============================] - 0s 4ms/step - loss: 0.9608 - accura
cy: 0.7353
Epoch 100/200
2/2 [==============================] - 0s 5ms/step - loss: 0.9370 - accura
cy: 0.7353
Epoch 101/200
2/2 [==============================] - 0s 4ms/step - loss: 0.9170 - accura
cy: 0.7647
Epoch 102/200
2/2 [==============================] - 0s 5ms/step - loss: 0.8931 - accura
cy: 0.7353
Epoch 103/200
2/2 [==============================] - 0s 5ms/step - loss: 0.8726 - accura
cy: 0.7941
Epoch 104/200
2/2 [==============================] - 0s 4ms/step - loss: 0.8485 - accura
cy: 0.8235
Epoch 105/200
2/2 [==============================] - 0s 4ms/step - loss: 0.8299 - accura
cy: 0.8235
Epoch 106/200
2/2 [==============================] - 0s 4ms/step - loss: 0.8118 - accura
cy: 0.7941
Epoch 107/200
2/2 [==============================] - 0s 5ms/step - loss: 0.7897 - accura
cy: 0.7647
Epoch 108/200
2/2 [==============================] - 0s 4ms/step - loss: 0.7610 - accura
cy: 0.8529
Epoch 109/200
2/2 [==============================] - 0s 4ms/step - loss: 0.7359 - accura
cy: 0.8824
Epoch 110/200
2/2 [==============================] - 0s 4ms/step - loss: 0.7151 - accura
cy: 0.8824
Epoch 111/200
2/2 [==============================] - 0s 5ms/step - loss: 0.7002 - accura
cy: 0.8824
Epoch 112/200
2/2 [==============================] - 0s 5ms/step - loss: 0.6869 - accura
cy: 0.8529
Epoch 113/200
2/2 [==============================] - 0s 5ms/step - loss: 0.6746 - accura
cy: 0.8529
Epoch 114/200
2/2 [==============================] - 0s 5ms/step - loss: 0.6585 - accura
cy: 0.8824
Epoch 115/200
2/2 [==============================] - 0s 4ms/step - loss: 0.6416 - accura
cy: 0.8824
Epoch 116/200
2/2 [==============================] - 0s 4ms/step - loss: 0.6259 - accura
cy: 0.8529
Epoch 117/200
2/2 [==============================] - 0s 5ms/step - loss: 0.6151 - accura
cy: 0.8235
Epoch 118/200
2/2 [==============================] - 0s 5ms/step - loss: 0.6096 - accura
cy: 0.8529
```

```
Epoch 119/200
2/2 [==============================] - 0s 5ms/step - loss: 0.5996 - accura
cy: 0.8529
Epoch 120/200
2/2 [==============================] - 0s 5ms/step - loss: 0.5900 - accura
cy: 0.8529
Epoch 121/200
2/2 [==============================] - 0s 5ms/step - loss: 0.5838 - accura
cy: 0.8529
Epoch 122/200
2/2 [==============================] - 0s 4ms/step - loss: 0.5671 - accura
cy: 0.9118
Epoch 123/200
2/2 [==============================] - 0s 4ms/step - loss: 0.5477 - accura
cy: 0.9118
Epoch 124/200
2/2 [==============================] - 0s 5ms/step - loss: 0.5283 - accura
cy: 0.9118
Epoch 125/200
2/2 [==============================] - 0s 5ms/step - loss: 0.5089 - accura
cy: 0.9412
Epoch 126/200
2/2 [==============================] - 0s 5ms/step - loss: 0.4923 - accura
cy: 0.9412
Epoch 127/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4824 - accura
cy: 0.9412
Epoch 128/200
2/2 [==============================] - 0s 6ms/step - loss: 0.4719 - accura
cy: 0.9118
Epoch 129/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4604 - accura
cy: 0.9118
Epoch 130/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4495 - accura
cy: 0.9118
Epoch 131/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4395 - accura
cy: 0.9118
Epoch 132/200
2/2 [==============================] - 0s 5ms/step - loss: 0.4290 - accura
cy: 0.8824
Epoch 133/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4181 - accura
cy: 0.8824
Epoch 134/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4088 - accura
cy: 0.8824
Epoch 135/200
2/2 [==============================] - 0s 4ms/step - loss: 0.4003 - accura
cy: 0.9412
Epoch 136/200
2/2 [==============================] - 0s 5ms/step - loss: 0.3955 - accura
cy: 0.9412
Epoch 137/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3897 - accura
cy: 0.8529
Epoch 138/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3877 - accura
```

```
cy: 0.8824
Epoch 139/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3865 - accura
cy: 0.8529
Epoch 140/200
2/2 [==============================] - 0s 5ms/step - loss: 0.3853 - accura
cy: 0.9118
Epoch 141/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3803 - accura
cy: 0.9118
Epoch 142/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3717 - accura
cy: 0.9412
Epoch 143/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3635 - accura
cy: 0.9118
Epoch 144/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3580 - accura
cy: 0.9118
Epoch 145/200
2/2 [==============================] - 0s 5ms/step - loss: 0.3514 - accura
cy: 0.8824
Epoch 146/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3428 - accura
cy: 0.8824
Epoch 147/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3314 - accura
cy: 0.9118
Epoch 148/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3259 - accura
cy: 0.9118
Epoch 149/200
2/2 [==============================] - 0s 5ms/step - loss: 0.3163 - accura
cy: 0.8824
Epoch 150/200
2/2 [==============================] - 0s 5ms/step - loss: 0.3100 - accura
cy: 0.9118
Epoch 151/200
2/2 [==============================] - 0s 4ms/step - loss: 0.3049 - accura
cy: 0.9118
Epoch 152/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2994 - accura
cy: 0.9118
Epoch 153/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2920 - accura
cy: 0.9118
Epoch 154/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2775 - accura
cy: 0.9118
Epoch 155/200
2/2 [==============================] - 0s 5ms/step - loss: 0.2645 - accura
cy: 0.9118
Epoch 156/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2571 - accura
cy: 0.9412
Epoch 157/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2510 - accura
cy: 0.9412
Epoch 158/200
```

```
2/2 [==============================] - 0s 4ms/step - loss: 0.2466 - accura
cy: 0.9706
Epoch 159/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2408 - accura
cy: 0.9706
Epoch 160/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2345 - accura
cy: 1.0000
Epoch 161/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2274 - accura
cy: 1.0000
Epoch 162/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2215 - accura
cy: 1.0000
Epoch 163/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2152 - accura
cy: 1.0000
Epoch 164/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2091 - accura
cy: 1.0000
Epoch 165/200
2/2 [==============================] - 0s 5ms/step - loss: 0.2034 - accura
cy: 1.0000
Epoch 166/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1991 - accura
cy: 1.0000
Epoch 167/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1926 - accura
cy: 1.0000
Epoch 168/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1884 - accura
cy: 1.0000
Epoch 169/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1856 - accura
cy: 1.0000
Epoch 170/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1845 - accura
cy: 1.0000
Epoch 171/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1873 - accura
cy: 0.9706
Epoch 172/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1934 - accura
cy: 0.9706
Epoch 173/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1990 - accura
cy: 0.9118
Epoch 174/200
2/2 [==============================] - 0s 4ms/step - loss: 0.2012 - accura
cy: 0.9118
Epoch 175/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1981 - accura
cy: 0.9118
Epoch 176/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1921 - accura
cy: 0.9118
Epoch 177/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1842 - accura
cy: 0.9412
```

```
Epoch 178/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1758 - accura
cy: 0.9706
Epoch 179/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1674 - accura
cy: 0.9706
Epoch 180/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1599 - accura
cy: 0.9706
Epoch 181/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1582 - accura
cy: 0.9706
Epoch 182/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1619 - accura
cy: 0.9706
Epoch 183/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1653 - accura
cy: 0.9706
Epoch 184/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1593 - accura
cy: 0.9706
Epoch 185/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1546 - accura
cy: 0.9706
Epoch 186/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1595 - accura
cy: 0.9412
Epoch 187/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1682 - accura
cy: 0.9412
Epoch 188/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1730 - accura
cy: 0.9412
Epoch 189/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1718 - accura
cy: 0.9412
Epoch 190/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1660 - accura
cy: 0.9412
Epoch 191/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1569 - accura
cy: 0.9412
Epoch 192/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1465 - accura
cy: 0.9412
Epoch 193/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1364 - accura
cy: 0.9706
Epoch 194/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1276 - accura
cy: 0.9706
Epoch 195/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1220 - accura
cy: 0.9706
Epoch 196/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1170 - accura
cy: 0.9706
Epoch 197/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1156 - accura
```

```
cy: 0.9706
Epoch 198/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1093 - accura
cy: 1.0000
Epoch 199/200
2/2 [==============================] - 0s 5ms/step - loss: 0.1056 - accura
cy: 1.0000
Epoch 200/200
2/2 [==============================] - 0s 4ms/step - loss: 0.1119 - accura
cy: 0.9706
```

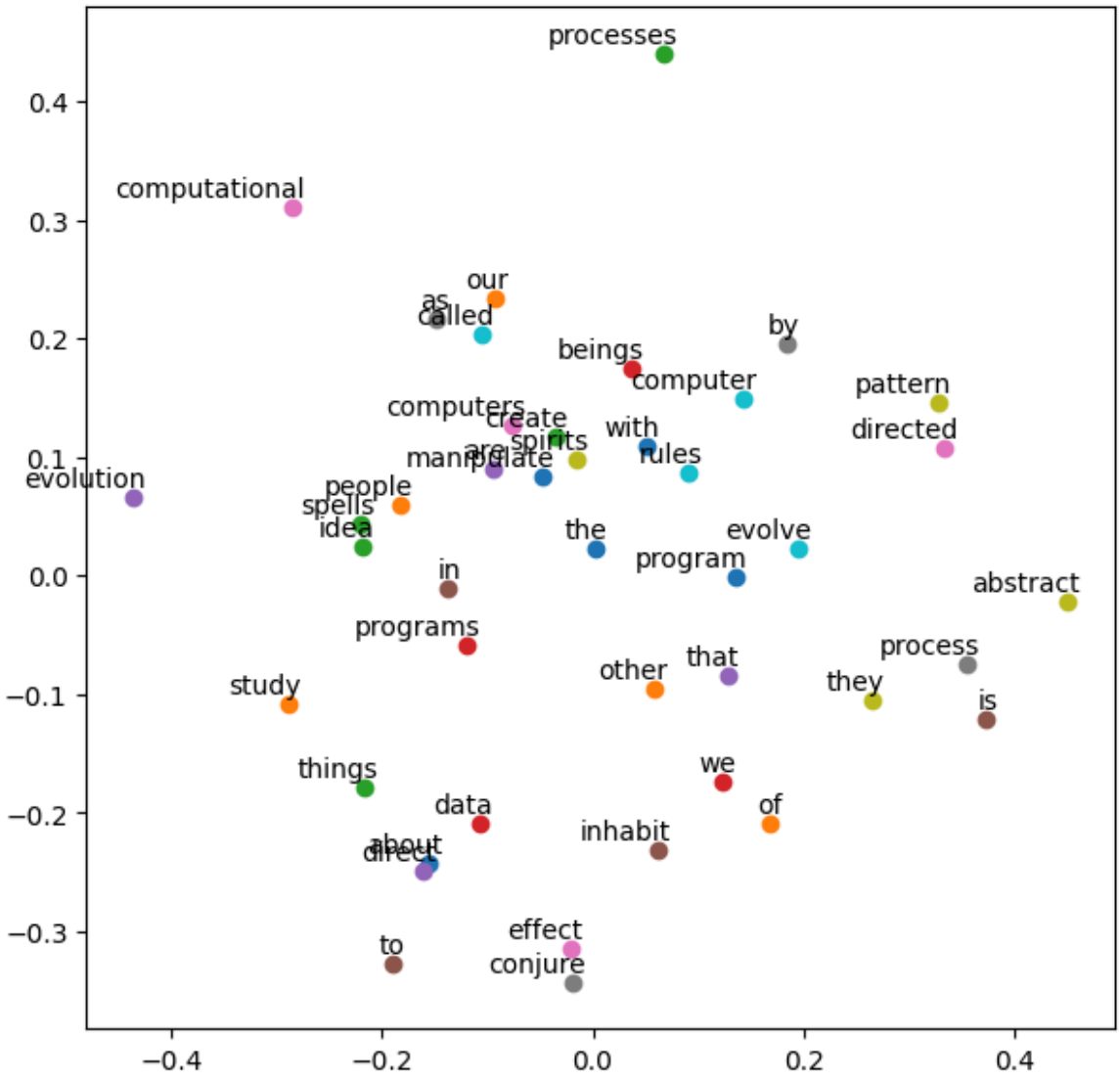
Out[15]: <keras.src.callbacks.History at 0x7f9a47db7690>

In [16]:
```
# Get the word embeddings
embeddings = model.get_weights()[0]

# Perform PCA to reduce the dimensionality of the embeddings
pca = PCA(n_components=2)
reduced_embeddings = pca.fit_transform(embeddings)
```

d. Output

In [17]:
```
# Visualize the embeddings
plt.figure(figsize=(7, 7))
for i, word in enumerate(tokenizer.word_index.keys()):
    x, y = reduced_embeddings[i]
    plt.scatter(x, y)
    plt.annotate(word, xy=(x, y), xytext=(5, 2),
                 textcoords='offset points',
                 ha='right', va='bottom')
plt.show()
```



In [18]:
```
# test model
test_sentenses = [
    "we are to study",
    "create programs direct processes",
    "spirits process study program",
    "idea study people create"
]
```

In [19]:
```
for test_sentense in test_sentenses:
    test_words = test_sentense.split(" ")
    print("Words: ", test_words)
    x_test = []
    for i in test_words:
        x_test.append(word_to_index_map.get(i))
    x_test = np.array([x_test])
    print("Indexs: ", x_test)
    test_predictions = model.predict(x_test)
    y_pred = np.argmax(test_predictions[0])
    print("Predictons: ",test_words, " => ", index_to_word_map.get(y_pred)
    print("\n")
```

```
Words:  ['we', 'are', 'to', 'study']
Indexs:  [[ 4  5  6 12]]
1/1 [==============================] - 0s 58ms/step
Predictons:  ['we', 'are', 'to', 'study']  =>  about


Words:  ['create', 'programs', 'direct', 'processes']
Indexs:  [[33 34 35  3]]
1/1 [==============================] - 0s 14ms/step
Predictons:  ['create', 'programs', 'direct', 'processes']  =>  to


Words:  ['spirits', 'process', 'study', 'program']
Indexs:  [[39  8 12 31]]
1/1 [==============================] - 0s 13ms/step
Predictons:  ['spirits', 'process', 'study', 'program']  =>  are


Words:  ['idea', 'study', 'people', 'create']
Indexs:  [[13 12 32 33]]
1/1 [==============================] - 0s 13ms/step
Predictons:  ['idea', 'study', 'people', 'create']  =>  programs
```