



ACTIVIDAD 12: EL ÁRBOL BINARIO DE BÚSQUEDA, IMPLEMENTACIÓN DINÁMICA

ESTUDIANTE: EFRAIN ROBLES PULIDO

CODIGO: 221350095

NOMBRE DE LA MATERIA: ESTRUCTURAS DE DATOS I

SECCIÓN: D12

CLAVE: I5886

FECHA: DOMINGO 10 DE ABRIL DE 2022

Tabla de autoevaluación:

Autoevaluación			
Concepto	Sí	No	Acumulación
Bajé el trabajo de internet o alguien me lo pasó (aunque sea de forma parcial)	-100 pts	0 pts	0 pts
Incluí el código fuente en formato de texto (sólo si funciona cumpliendo todos los requerimientos)	+25 pts	0 pts	25 pts
Incluí las impresiones de pantalla (sólo si funciona cumpliendo todos los requerimientos)	+25 pts	0 pts	25 pts
Incluí una portada que identifica mi trabajo (nombre, código, materia, fecha, título)	+25 pts	0 pts	25 pts
Incluí una descripción y conclusiones de mi trabajo	+25 pts	0 pts	25 pts
Suma:			100 pts

Introducción:

Después de leer las instrucciones de la plataforma, se reutilizo el código de la lista doblemente ligada en donde se usa dos apuntadores en sus nodos para adaptarlo al funcionamiento de árbol binario de búsqueda, con memoria dinámica. Después de hacer las modificaciones mostradas en los videos de la plataforma, realicé los métodos faltantes de los videos, como el deleteData, deleteAll y el copyAll, en donde tuve que investigar y consultar mucha información de los árboles binarios de búsqueda y de la recursividad para poder desarrollarlo correctamente. Tuve que aplicar la recursividad y utilizar métodos interfaces para siguiera el modelo de que cada recorrido sea un subárbol. En donde por cada método se utilizaron dos métodos por cada uno, uno que inicia el método con la raíz original y otro para que sea recursivo trabajando con el subárbol consecutivamente hasta que nuestro criterio de para sea el valor nulo, utilizando las direcciones de memoria y/o el valor de nuestro dato a manejar. Para el método de deleteData se empieza con el nodo de nuestra raíz y el valor a eliminar, en donde utilizamos el modelo de la búsqueda binaria para encontrar la dirección de memoria para irse hacia la izquierda o derecha según el valor a buscar y el valor del nodo actual, una vez encontrado se sigue el modelo para eliminar en un subárbol, si es hoja se elimina y libera espacio, si tiene un hijo se sobrescribirá el valor del nodo hijo hacia el padre para liberar espacio. Para el método deleteAll, se hace un recorrido postOrder en donde vamos liberando espacios de memoria, para que, una vez terminado la recursividad, a la raíz del árbol le asignaremos nulo. Y para el método copyAll se hizo un recorrido preOrder, iniciando la recursividad con la raíz original y la de destino,

en donde se estará creando los nodos al árbol destino con el valor del nodo actual del árbol original, incluyendo el valor nulo.

Finalmente realice el código principal en donde utilizo funciones de la librería chrono para crear los números aleatorios e incluí la clase Integer para usarlo con la plantilla del árbol binario de búsqueda.

Código fuente:

```
/*Efrain Robles Pulido*/
#include "Menu.h"
#include "Integer.h"
#include <iostream>

using namespace std;

int main() {
    BTree<Integer> myTree;
    Menu interfaz(myTree);
    interfaz.mainMenu();
    return 0;
}

#ifndef MENU_H_INCLUDED
#define MENU_H_INCLUDED

#include "BTree.h"
#include "Integer.h"

#include <iostream>
#include <random>
#include <chrono>
#include <conio.h>
#include <functional>

class Menu {
private:
    ///Atributos
    BTree<Integer>* myBTree;

    ///Metodos Privados
    void enterMenu();

public:
    ///Constructor
    Menu(BTree<Integer>&);

    ///Metodo publico
    void mainMenu();
};
```

```

#endif // MENU_H_INCLUDED

#include "Menu.h"

using namespace std;
using namespace std::chrono;

///Metodo privado
void Menu::enterMenu() {
    cout<< endl<< "Presiona cualquier tecla para continuar";
    getch();
}

///Constructor
Menu::Menu(BTree<Integer>& _BTree): myBTree(&_BTree) {}

///Metodo publico
void Menu::mainMenu() {
    int i(0), N;
    Integer myInt;
    BTree<Integer>::Position theRoot;

    cout<<"\t\t\tARBOLES BINARIOS DE BUSQUEDA"<<endl<<endl<<"Ingrese N
valores a utilizar: ";
    cin>>N;
    cout<<endl<<"->Valores generados: "<<endl;

    std::default_random_engine
generator(chrono::system_clock::now().time_since_epoch().count());
    std::uniform_int_distribution<long long int> distribution(0,100000);
    auto randomInt = bind(distribution, generator);

    while(i < N) {
        myInt.setInteger(randomInt());
        myBTree->insertData(myInt);
        cout<<myInt.toString() + ", ";
        if(i==0) {
            theRoot = myBTree->findData(myInt);
        }
        i++;
    }

    cout<<endl<<endl<<"->PreOrder: "<<endl;
    myBTree->parsePreOrder();

    cout<<endl<<endl<<"->InOrder: "<<endl;
    myBTree->parseInOrder();

    cout<<endl<<endl<<"->PostOrder: "<<endl;
    myBTree->parsePostOrder();

    cout<<endl<<endl<<"->Elemento menor: "<< myBTree->getLowest()-
>getData().toString();

    cout<<endl<<endl<<"->Elemento mayor: "<<myBTree->getHighest()-
>getData().toString()<<endl;

```

```

        cout<<endl<<"->Altura de Subarbol Izquierdo, respecto a la Raiz del
Arbol: "<<myBTree->getHeight(theRoot->getLeft())<<endl;

```

```

        cout<<endl<<"->Altura de Subarbol Derecho, respecto a la Raiz del
Arbol: "<<myBTree->getHeight(theRoot->getRight())<<endl;

```

```

    enterMenu();

```

```

}

```

```

#ifndef BTREE_H_INCLUDED
#define BTREE_H_INCLUDED

```

```

#include <iostream>
#include <string>
#include <exception>

```

```

///Definicion del Arbol

```

```

template <class T>

```

```

class BTree {

```

```

    private:

```

```

        ///Definicion del Nodo

```

```

        class Node {

```

```

            private:

```

```

                T* dataPtr;
                Node* left;
                Node* right;

```

```

        public:

```

```

            ///Definicion de Excepcion para el Nodo

```

```

            class Exception : public std::exception {

```

```

                private:

```

```

                    std::string msg;

```

```

                public:

```

```

                    explicit Exception(const char* message):

```

```

msg(message) {}

```

```

                    explicit Exception(const std::string& message):

```

```

msg(message) {}

```

```

                    virtual ~Exception() throw() {}

```

```

                    virtual const char* what() const throw () {

```

```

                        return msg.c_str();

```

```

                    }

```

```

            };

```

```

        Node();

```

```

        Node(const T&);

```

```

        ~Node();

```

```

        T* getDataPtr() const;

```

```

        T getData() const;

```

```

        Node*& getLeft();

```

```

        Node*& getRight();

```

```

        void setDataPtr(T*);

```

```

        void setData(const T&);

```

```

        void setLeft(Node*&);

```

```

        void setRight (Node*&);
    };

public:
    typedef Node* Position;

    ///Definicion de Excepcion para el arbol
    class Exception : public std::exception {
    private:
        std::string msg;
    public:
        explicit Exception(const char* message): msg(message) {}
        explicit Exception(const std::string& message):
msg(message) {}
        virtual ~Exception() throw() {}
        virtual const char* what() const throw () {
            return msg.c_str();
        }
    };

private:
    Position root;

    void copyAll (BTree<T>&);

    void insertData (Position&, const T&);
    void deleteData (Position&, const T&);
    Position& findData (Position&, const T&);

    Position& getLowest (Position&);
    Position& getHighest (Position&);

    void parsePostOrderDeleteAll (Position&);

    void parsePreOrderCopy (Position&, Position&);

    void parsePreOrder (Position&);
    void parseInOrder (Position&);
    void parsePostOrder (Position&);

public:
    ///Constructores
    BTree();
    BTree(BTree<T>&);
    ~BTree(); ///Destructor

    ///Sobrecarga de operador
    BTree<T>& operator = (const BTree<T>&);

    ///Metodos para un Arbol
    bool isEmpty() const;

    void insertData(const T&);
    void deleteData(const T&);
    void deleteAll();

```

```

        T retrieve(Position&) const;

        Position& findData(const T&);
        Position& getLowest();
        Position& getHighest();

        bool isLeaf(Position&);

        int getHeight(Position&);
        int getHeight();

        void parsePreOrder();
        void parseInOrder();
        void parsePostOrder();
    };

    ///Implementacion
    using namespace std;

    ///del Nodo
    template <class T>
    BTree<T>::Node::Node():dataPtr(nullptr), left(nullptr), right(nullptr) {}

    template <class T>
    BTree<T>::Node::Node(const T& e): dataPtr(new T(e)), left(nullptr),
    right(nullptr) {
        if(dataPtr == nullptr) {
            throw Exception("Memoria insuficiente, creando nodo");
        }
    }

    template <class T>
    BTree<T>::Node::~~Node() {
        delete dataPtr;
    }

    template <class T>
    T* BTree<T>::Node::getDataPtr() const {
        return dataPtr;
    }

    template <class T>
    T BTree<T>::Node::getData() const {
        if(dataPtr == nullptr) {
            throw Exception("Dato inexistente, getData");
        }

        return *dataPtr;
    }

    template <class T>
    typename BTree<T>::Position& BTree<T>::Node::getLeft() {
        return left;
    }

    template <class T>
    typename BTree<T>::Position& BTree<T>::Node::getRight() {

```

```

        return right;
    }

template <class T>
void BTree<T>::Node::setDataPtr(T* e) {
    dataPtr = e;
}

template <class T>
void BTree<T>::Node::setData(const T& e) {
    if(dataPtr == nullptr) {
        if((dataPtr = new T(e)) == nullptr) {
            throw Exception("Memoria no disponible, setData");
        }
    }
    else {
        *dataPtr = e;
    }
}

template <class T>
void BTree<T>::Node::setLeft(Node*& p) {
    left = p;
}

template <class T>
void BTree<T>::Node::setRight(Node*& p) {
    right = p;
}

///del Arbol
///Metodos privados
template <class T>
void BTree<T>::copyAll(BTree<T>& t) {
    parsePreOrderCopy(root, t.root);
}

template <class T>
void BTree<T>::insertData(Position& r, const T& e) {
    if(r == nullptr) {
        try {
            if((r = new Node(e)) == nullptr) {
                throw Exception("Memoria no disponible, insertData");
            }
        }
        catch (typename Node::Exception ex) {
            throw Exception(ex.what());
        }
    }
    else {
        if(e < r->getData()) {
            insertData(r->getLeft(), e);
        }
        else {
            insertData(r->getRight(), e);
        }
    }
}

```



```

template <class T>
void BTree<T>::deleteData(Position& r, const T& e) {
    if(isEmpty()) {
        return;
    }
    if(e == r->getData()) {
        if(isLeaf(r)) { //Si es hoja
            delete r;
            r = nullptr;
            return;
        }
        else if(r->getRight() == nullptr or r->getLeft() == nullptr)
        { //Si tiene un hijo
            Position aux(r);
            r = r->getLeft() == nullptr? r->getRight():r->getLeft();
            delete aux;
            return;
        }
        //Si tiene dos hijos
        T substitution(getHighest(r->getLeft())->getData());
        r->setData(substitution);
        deleteData(r->getLeft(), substitution);

    }
    else {
        if(e < r->getData()) {
            deleteData(r->getLeft(), e);
        }
        else {
            deleteData(r->getRight(), e);
        }
    }
}

template <class T>
typename BTree<T>::Position& BTree<T>::findData (Position& r, const T& e)
{
    if(r == nullptr or r->getData() == e) {
        return r;
    }
    if(e < r->getData()) {
        return findData(r->getLeft(), e);
    }
    return findData(r->getRight(), e);
}

template <class T>
typename BTree<T>::Position& BTree<T>::getLowest (Position& r) {
    if(r == nullptr or r->getLeft() == nullptr) {
        return r;
    }
    return getLowest(r->getLeft());
}

template <class T>

```

```

typename BTree<T>::Position& BTree<T>::getHighest (Position& r) {
    if(r == nullptr or r->getRight() == nullptr) {
        return r;
    }
    return getHighest(r->getRight());
}

template <class T>
void BTree<T>::parsePostOrderDeleteAll (Position& r) {
    if(r == nullptr) {
        return;
    }

    parsePostOrderDeleteAll(r->getLeft());
    parsePostOrderDeleteAll(r->getRight());
    delete r;
}

template <class T>
void BTree<T>::parsePreOrderCopy (Position& r, Position& rCopy) {
    if(rCopy == nullptr) {
        r = nullptr;
    }
    else {
        try {
            if((r = new Node(rCopy->getData())) == nullptr) {
                throw Exception("Memoria no disponible, copyAll");
            }
        }
        catch (typename Node::Exception ex) {
            throw Exception(ex.what());
        }

        parsePreOrderCopy(r->getLeft(), rCopy->getLeft());
        parsePreOrderCopy(r->getRight(), rCopy->getRight());
    }
}

template <class T>
void BTree<T>::parsePreOrder (Position& r) {
    if(r == nullptr) {
        return;
    }

    std::cout << r->getData().toString() << ", ";
    parsePreOrder(r->getLeft());
    parsePreOrder(r->getRight());
}

template <class T>
void BTree<T>::parseInOrder (Position& r) {
    if(r == nullptr) {
        return;
    }

    parseInOrder(r->getLeft());
    cout << r->getData().toString() << ", ";
    parseInOrder(r->getRight());
}

```

```

    }

template <class T>
void BTree<T>::parsePostOrder (Position& r) {
    if(r == nullptr) {
        return;
    }
    parsePostOrder(r->getLeft());
    parsePostOrder(r->getRight());
    cout << r->getData().toString() << ", ";
}

///Constructores
template <class T>
BTree<T>::BTree(): root(nullptr) {}

template <class T>
BTree<T>::BTree(BTree<T>& t): BTree() { //Llama otra vez al constructor
    copyAll(t);
}

template <class T>
BTree<T>::~~BTree() { //Destructor
    deleteAll();
}

///Sobre carga de operador
template <class T>
BTree<T>& BTree<T>::operator =(const BTree<T>&t) {
    deleteAll();
    copyAll(t);
    return *this;
}

///Metodos publicos de la BTreea
template <class T>
bool BTree<T>::isEmpty() const {
    return root == nullptr;
}

template <class T>
void BTree<T>::insertData(const T& e) {
    insertData(root, e);
}

template <class T>
void BTree<T>::deleteData(const T& e) {
    deleteData(root, e);
}

template <class T>
void BTree<T>::deleteAll() {
    parsePostOrderDeleteAll(root);
    root = nullptr;
}

template <class T>
T BTree<T>::retrieve(Position& r) const {

```

```

        return r->getData();
    }

template <class T>
typename BTree<T>::Position& BTree<T>::findData(const T& e) {
    return findData(root, e);
}

template <class T>
typename BTree<T>::Position& BTree<T>::getLowest() {
    return getLowest(root);
}

template <class T>
typename BTree<T>::Position& BTree<T>::getHighest() {
    return getHighest(root);
}

template <class T>
bool BTree<T>::isLeaf(Position& r) {
    return r != nullptr and r->getLeft() == r->getRight();
}

template <class T>
int BTree<T>::getHeight() {
    return getHeight(root);
}

template <class T>
int BTree<T>::getHeight(Position& r) {
    if(r == nullptr) {
        return 0;
    }
    int lH(getHeight(r->getLeft()));
    int rH(getHeight(r->getRight()));

    return (lH > rH ? lH : rH) + 1;
}

template <class T>
void BTree<T>::parsePreOrder () {
    parsePreOrder(root);
}

template <class T>
void BTree<T>::parseInOrder () {
    parseInOrder(root);
}

template <class T>
void BTree<T>::parsePostOrder () {
    parsePostOrder(root);
}

#endif // BTREE_H_INCLUDED

```

```

#ifndef INTEGER_H_INCLUDED
#define INTEGER_H_INCLUDED

#include <iostream>
#include <string>

class Integer {
private:
    long long int data;

public:
    Integer();

    Integer(const Integer&);

    Integer(const long long int&);

    std::string toString() const;

    void setInteger(const long long int&);

    long long int getInteger() const;

    Integer& operator ++ ();

    Integer operator ++ (int);

    Integer& operator -- ();

    Integer operator -- (int);

    Integer operator + (const Integer&) const;

    Integer operator - (const Integer&) const;

    Integer operator * (const Integer&) const;

    Integer operator / (const Integer&) const;

    Integer operator % (const Integer&) const;

    Integer operator - () const;

    Integer& operator = (const Integer&);

    Integer& operator += (const Integer&);

    Integer& operator -= (const Integer&);

    Integer& operator *= (const Integer&);

    Integer& operator /= (const Integer&);

    Integer& operator %= (const Integer&);

```

```

        bool operator == (const Integer&) const;

        bool operator != (const Integer&) const;

        bool operator < (const Integer&) const;

        bool operator <= (const Integer&) const;

        bool operator > (const Integer&) const;

        bool operator >= (const Integer&) const;

};

#endif // INTEGER_H_INCLUDED

#include <iostream>
#include <string>

#include "Integer.h"

using namespace std;

///Costructor
Integer::Integer() {}

Integer::Integer(const Integer& _integer): data(_integer.data) {}

Integer::Integer(const long long int& _data) : data(0) {}

string Integer::toString() const {
    return to_string(data);
}

void Integer::setInteger(const long long int& i) {
    data = i;
}

long long int Integer::getInteger() const {
    return data;
}

Integer& Integer::operator++() { //Version prefija
    return *this;
}

Integer Integer::operator++(int) { //Version postfija
    Integer old = *this;
    operator++();
    return old;
}

Integer& Integer::operator--() { //Version prefija
    return *this;
}

```

```

Integer Integer::operator--(int) { //Version postfija
    Integer old = *this;
    operator--();
    return old;
}

Integer Integer::operator+(const Integer& i) const {
    return data + i.data;
}

Integer Integer::operator-(const Integer& i) const {
    return data - i.data;
}

Integer Integer::operator*(const Integer& i) const {
    return data * i.data;
}

Integer Integer::operator/(const Integer& i) const {
    return data / i.data;
}

Integer Integer::operator%(const Integer& i) const {
    return data % i.data;
}

Integer Integer::operator-() const {
    return data;
}

Integer& Integer::operator=(const Integer& i) {
    data = i.data;
    return *this;
}

Integer& Integer::operator+=(const Integer& i) {
    data = data + i.data;
    return *this;
}

Integer& Integer::operator-=(const Integer& i) {
    return *this = *this - i.data;
}

Integer& Integer::operator*=(const Integer& i) {
    return *this = *this * i.data;
}

Integer& Integer::operator/=(const Integer& i) {
    return *this = *this / i.data;
}

Integer& Integer::operator%=(const Integer& i) {
    return *this = *this % i.data;
}

bool Integer::operator==(const Integer& i) const {

```

```

return data == i.data;
}

bool Integer::operator!=(const Integer& i) const {
    return !(*this == i);
}

bool Integer::operator<(const Integer& i) const {
    return data < i.data;
}

bool Integer::operator<=(const Integer& i) const {
    return (*this < i) or (*this == i);
}

bool Integer::operator>(const Integer& i) const {
    return !(*this <= i);
}

bool Integer::operator>=(const Integer& i) const {
    return !(*this < i);
}

```

```

ARBOLES BINARIOS DE BUSQUEDA

Ingrese N valores a utilizar: 1100

->Valores generados:
93695, 72446, 53655, 52047, 32586, 58084, 81180, 48566, 30002, 33676, 83650, 64106, 97931, 68844, 31246, 34199, 66868, 22765, 132, 28300, 31274, 4959, 43747, 36258, 80761, 97294
, 57708, 66853, 63786, 22647, 19265, 77355, 64138, 31000, 96979, 72074, 3713, 15495, 14655, 12441, 97671, 3926, 94429, 13948, 28076, 58607, 79800, 47286, 12359, 24863, 63047, 27
51, 49204, 52327, 31338, 91872, 48689, 92196, 93782, 45689, 71587, 29062, 37935, 48898, 99270, 78873, 71058, 36337, 2541, 17023, 7163, 99660, 23360, 11187, 13930, 21088, 15173,
12155, 87593, 24026, 94574, 47385, 70008, 83546, 10421, 39050, 88561, 99183, 8072, 71839, 61546, 71227, 69249, 35717, 75500, 95419, 56584, 80038, 50919, 75497, 41109, 2716, 5914
6, 31788, 50359, 61420, 55422, 48989, 26098, 22884, 2152, 73275, 97357, 26766, 47253, 59543, 581, 78873, 67225, 22282, 82618, 16054, 11047, 75345, 85614, 71137, 62482, 1976, 142
06, 53959, 63862, 94066, 14408, 53200, 8152, 13741, 51778, 6405, 45678, 86585, 86213, 37086, 93621, 34203, 34041, 11600, 60615, 22382, 72474, 31656, 27687, 32123, 81812, 66418,
56039, 17573, 39351, 55073, 80481, 94115, 39300, 4531, 53508, 78999, 85835, 85687, 1181, 48877, 48090, 33625, 29084, 401, 50556, 77480, 63487, 93062, 46405, 12784, 53862, 37116,
86034, 23527, 5217, 93683, 83445, 21300, 88002, 98823, 55514, 91998, 58721, 90184, 68914, 97968, 95738, 8075, 20506, 42435, 78484, 30958, 2058, 95097, 47068, 44712, 52666, 3216
1, 21514, 83762, 43819, 49272, 88314, 43981, 70980, 27362, 57555, 91239, 1164, 66943, 83427, 9740, 190, 6548, 52412, 61043, 12470, 91057, 43399, 87348, 6240, 73875, 74153, 42971
, 97336, 76730, 67064, 9263, 89975, 51071, 30032, 33004, 86610, 12584, 97403, 91529, 80607, 13644, 11008, 8964, 61181, 29296, 59404, 75719, 68600, 25997, 23883, 97802, 7375, 537
62, 45329, 20057, 99057, 99454, 63807, 70932, 21836, 96480, 91255, 65663, 65416, 18651, 66141, 88642, 63627, 53444, 1466, 42085, 98291, 26208, 75291, 78694, 59093, 42185, 78826,
93461, 41551, 29029, 82788, 78972, 46949, 49064, 92608, 4372, 86783, 6061, 75211, 28469, 70500, 49668, 49036, 17571, 21015, 88344, 48331, 68585, 72218, 26950, 37380, 34738, 302
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->Elemento menor: 56
->Elemento mayor: 99660
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->Altura de Subarbol Derecho, respecto a la Raiz del Arbol: 11
Presiona cualquier tecla para continuar
Process returned 0 (0x0)   execution time : 5.532 s
Press any key to continue.
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ARBOLES BINARIOS DE BUSQUEDA

Ingrese N valores a utilizar: 1100

-->Valores generados:

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->Altura de Subarbol Derecho, respecto a la Raiz del Arbol: 23

Presiona cualquier tecla para continuar
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Press any key to continue.
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ARBOLES BINARIOS DE BUSQUEDA

Ingrese N valores a utilizar: 1100

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->Altura de Subarbol Derecho, respecto a la Raiz del Arbol: 18

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Conclusión:

Al principio pensé que estaría fácil el tema debido que seguía el mismo principio de la lista doblemente ligada, pero con una pequeña modificación, en donde se le adapto los punteros como derecha e izquierda en vez de siguiente y anterior como la anterior actividad, pero cuando tuve que crear el código para los métodos deleteData, copyAll y deleteAll, fue muy confuso porque antes me costaba mucho entender el tema de la recursividad, pero con esta actividad me ayudo a practicar y poner a prueba mis conocimientos sobre los nodos y el comportamiento del árbol binario de búsqueda y pude entenderla con la ayuda del profesor. Me llamo la atención que, para poder utilizar la recursividad, en la mayoría de los métodos, debemos de hacer dos métodos en donde uno nos sirva de inicio de la recursividad y el otro es que trabaja y sea recursivo el método, en donde en esta actividad se siguió el modelo de movernos de subárbol a subárbol. Finalmente, con esta actividad me fue interesante que el almacenamiento de información con el árbol binario de búsqueda es efectivo debido a que usamos direcciones de memorias y conforme se vayan almacenando se van ordenado según su valor, lo cual es muy importante tener esto muy claro para la siguiente actividad.