Untitled MMO Database Design Proof of Concept

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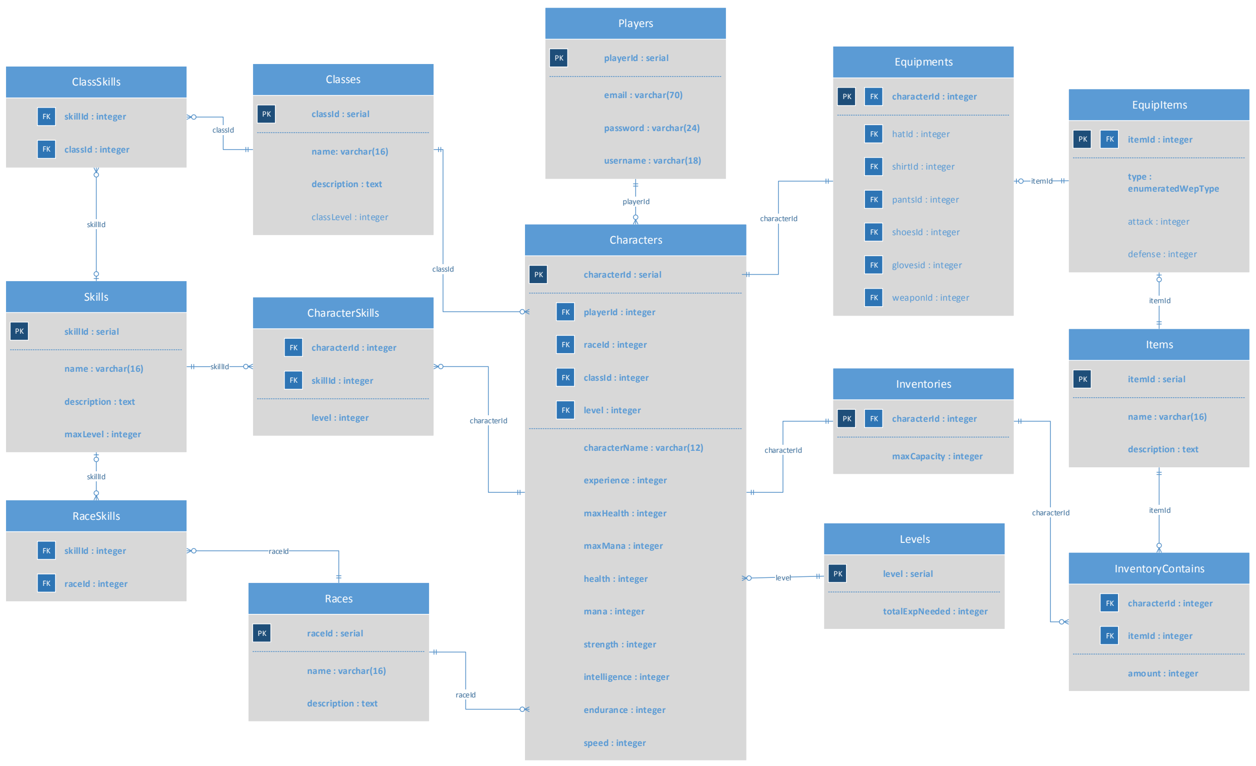
Executive Summary

This document represents the database design and implementation for the basics of an mmorpg game. The purpose of this database is to cover a part of database needed for building an mmo. This database includes players, their characters, as well as the characters' stats, class, race, skills, and items. This database acts as a proof of concept to best see how the data of players and application data can be best designed for an mmo in order to communicate between client and server with minimal effort. Thus the database is designed as needs for only minimally needed data. The goal is to design a normalized database capable of handling interactions of data quickly and safely.

Entity Relationship Diagram



Tables

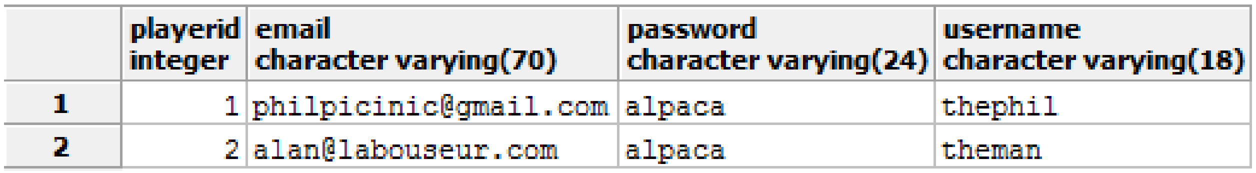
Players Table

The Players table lists all registered players and login information.

```
CREATE TABLE players(
	playerId SERIAL NOT NULL,
	email VARCHAR(70) NOT NULL UNIQUE,
	password VARCHAR(24) NOT NULL, -- password in plain text for this PoC
	username VARCHAR(18) NOT NULL UNIQUE,
	PRIMARY KEY (playerId)
);
```

Functional Dependencies: playerId -> email, password, username

Sample Data:



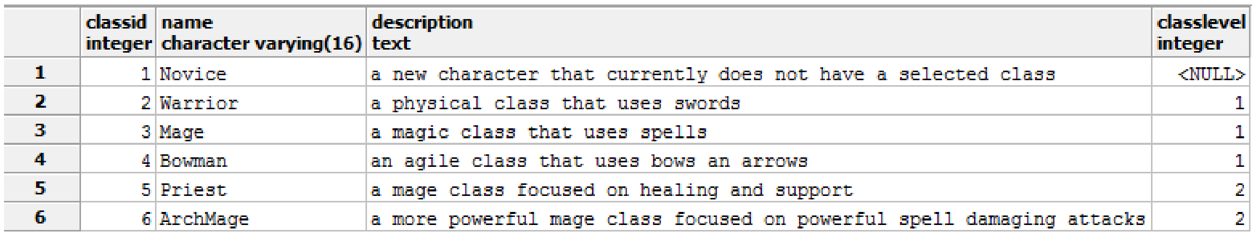
	playerid integer	email character varying(70)	password character varying(24)	username character varying(18)
1	1	philpicinic@gmail.com	alpaca	thephil
2	2	alan@labouseur.com	alpaca	theman

Classes Table
The classes table lists all possible classes of a character.

```
CREATE TABLE classes(
	classId SERIAL NOT NULL,
	name VARCHAR(16) NOT NULL UNIQUE,
	description TEXT NOT NULL,
	classLevel INTEGER,
	PRIMARY KEY (classId)
);
```

Functional Dependencies: classId -> name, description, classLevel

Sample Data:



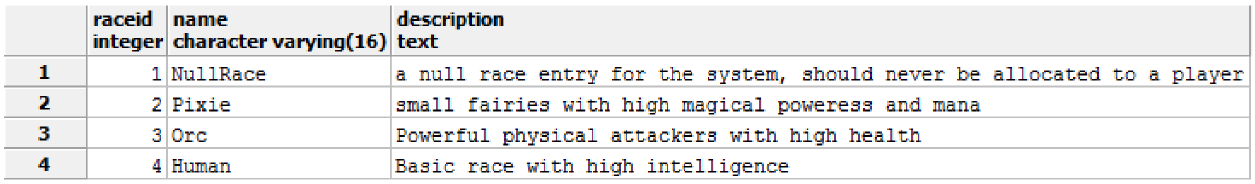
	classid integer	name character varying(16)	description text	classlevel integer
1	1	Novice	a new character that currently does not have a selected class	<NULL>
2	2	Warrior	a physical class that uses swords	1
3	3	Mage	a magic class that uses spells	1
4	4	Bowman	an agile class that uses bows an arrows	1
5	5	Priest	a mage class focused on healing and support	2
6	6	ArchMage	a more powerful mage class focused on powerful spell damaging attacks	2

Races Table
The races table lists all the possible races of a character.

```
CREATE TABLE races(
	raceId SERIAL NOT NULL,
	name VARCHAR(16),
	description TEXT,
	PRIMARY KEY(raceId)
);
```

Functional Dependencies: raceId -> name, description

Sample Data:



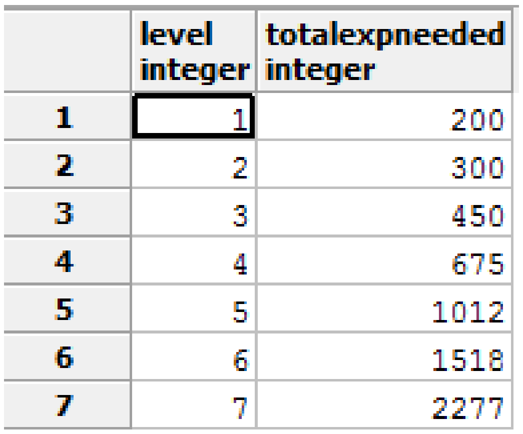
	raceid integer	name character varying(16)	description text
1	1	NullRace	a null race entry for the system, should never be allocated to a player
2	2	Pixie	small fairies with high magical poweress and mana
3	3	Orc	Powerful physical attackers with high health
4	4	Human	Basic race with high intelligence

Levels Table
The levels table lists all levels and required experience.

```
CREATE TABLE levels(
        level SERIAL NOT NULL,
        totalExpNeeded INTEGER NOT NULL,
        PRIMARY KEY(level)
);
```

Functional Dependencies: level -> totalExpNeeded

Sample Data:



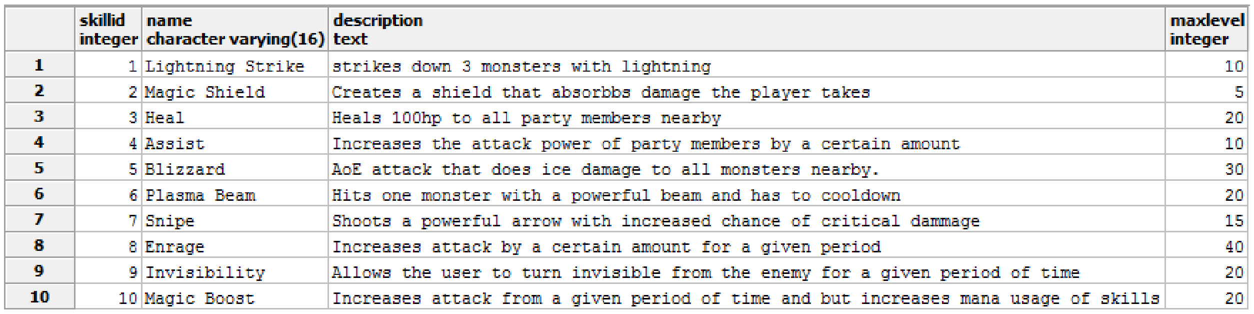
	level integer	totalexpneeded integer
1	1	200
2	2	300
3	3	450
4	4	675
5	5	1012
6	6	1518
7	7	2277

Skills Table
The skills table lists all the skills a character can have.

```
CREATE TABLE skills(
        skillId SERIAL NOT NULL,
        name VARCHAR(16) NOT NULL,
        description TEXT NOT NULL,
        maxLevel INTEGER NOT NULL,
        PRIMARY KEY (skillId)
);
```

Functional Dependencies: skillId -> name, description, maxLevel

Sample Data:



	skillid integer	name character varying(16)	description text	maxlevel integer
1	1	Lightning Strike	strikes down 3 monsters with lightning	10
2	2	Magic Shield	Creates a shield that absorbbs damage the player takes	5
3	3	Heal	Heals 100hp to all party members nearby	20
4	4	Assist	Increases the attack power of party members by a certain amount	10
5	5	Blizzard	AoE attack that does ice damage to all monsters nearby.	30
6	6	Plasma Beam	Hits one monster with a powerful beam and has to cooldown	20
7	7	Snipe	Shoots a powerful arrow with increased chance of critical dammage	15
8	8	Enrage	Increases attack by a certain amount for a given period	40
9	9	Invisibility	Allows the user to turn invisible from the enemy for a given period of time	20
10	10	Magic Boost	Increases attack from a given period of time and but increases mana usage of skills	20

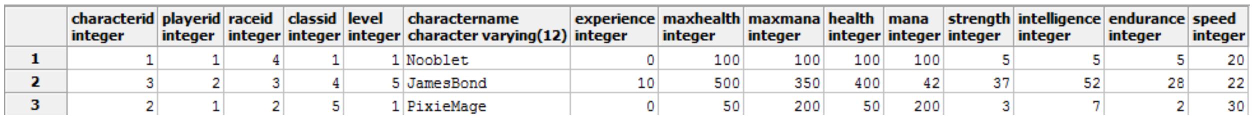
Characters Table
The characters table lists all playable characters belonging to players, their stats, and characteristics.

```
CREATE TABLE characters(
        characterId SERIAL NOT NULL,
        playerId INTEGER NOT NULL REFERENCES players(playerId),
        raceId INTEGER NOT NULL REFERENCES races(raceId) check(raceId != 1),
        classId INTEGER NOT NULL REFERENCES classes(classId),
        level INTEGER NOT NULL REFERENCES levels(level),
        characterName VARCHAR(12) NOT NULL UNIQUE,
        experience INTEGER NOT NULL,
        maxHealth INTEGER NOT NULL,
        maxMana INTEGER NOT NULL,
        health INTEGER NOT NULL check(health >= 0),
        mana INTEGER NOT NULL check(mana >= 0),
        strength INTEGER NOT NULL,
        intelligence INTEGER NOT NULL,
        endurance INTEGER NOT NULL,
        speed INTEGER NOT NULL,
        PRIMARY KEY (characterId),

        check(health <= maxHealth),
        check(mana <= maxMana)
);
```

Functional Dependencies: characterId -> playerId, raceId, classId, level, characterName, experience, maxHealth, maxMana, health, mana, strength, intelligence, endurance, speed

Sample Data:



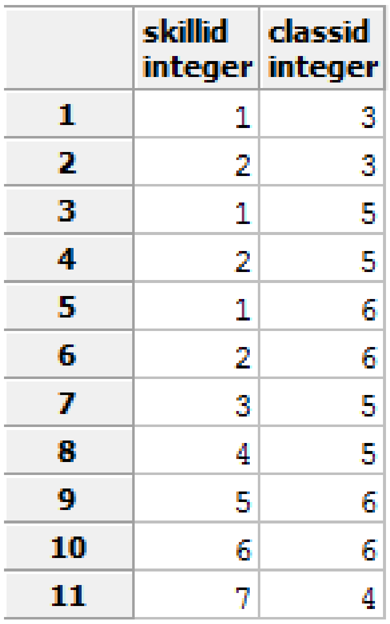
	characterid integer	playerid integer	raceid integer	classid integer	level integer	charactername character varying(12)	experience integer	maxhealth integer	maxmana integer	health integer	mana integer	strength integer	intelligence integer	endurance integer	speed integer
1	1	1	4	1	1	Nooblet	0	100	100	100	100	5	5	5	20
2	3	2	3	4	5	JamesBond	10	500	350	400	42	37	52	28	22
3	2	1	2	5	1	PixieMage	0	50	200	50	200	3	7	2	30

ClassSkills Table
Lists all skills a class can learn.

```
CREATE TABLE classSkills(
	skillId INTEGER NOT NULL REFERENCES skills(skillId),
	classId INTEGER NOT NULL REFERENCES classes(classId),
	PRIMARY KEY (skillId, classId)
);
```

Functional Dependencies: skillId, classId ->

Sample Data:



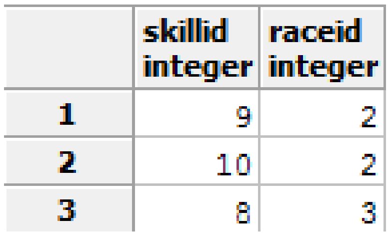
	skillid integer	classid integer
1	1	3
2	2	3
3	1	5
4	2	5
5	1	6
6	2	6
7	3	5
8	4	5
9	5	6
10	6	6
11	7	4

RaceSkills Table
Lists all skills a race can learn.

```
CREATE TABLE raceSkills(
	skillId INTEGER NOT NULL REFERENCES skills(skillId),
	raceId INTEGER NOT NULL REFERENCES races(raceId),
	PRIMARY KEY (skillId, raceId)
);
```

Functional Dependencies: skillId, raceId ->

Sample Data:



	skillid integer	raceid integer
1	9	2
2	10	2
3	8	3

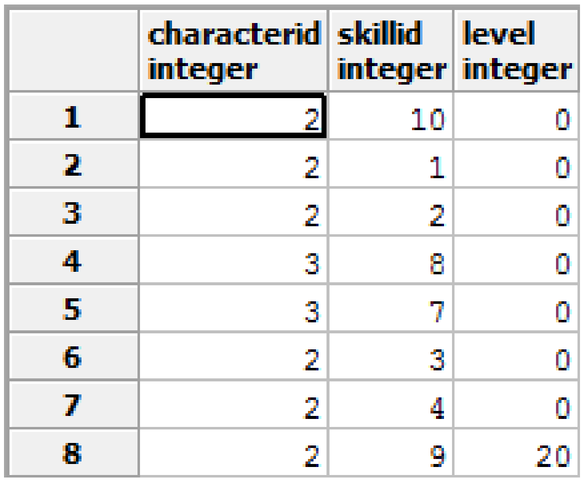
CharacterSkills Table
Lists all skills a characters knows and the level of the skill.

```
CREATE OR REPLACE FUNCTION checkSkillLevel(cid integer, sid integer, le integer)
RETURNS boolean AS $res$
DECLARE
        maxL integer;
BEGIN
        maxL = (SELECT maxLevel FROM skills WHERE skillId = sid);
        IF le > maxL THEN
                RETURN FALSE;
        END IF;
        RETURN TRUE;
END;
$res$ LANGUAGE plpgsql;

CREATE TABLE characterSkills(
        characterId INTEGER NOT NULL REFERENCES characters(characterId),
        skillId INTEGER NOT NULL REFERENCES skills(skillId),
        level INTEGER NOT NULL DEFAULT 0,
        PRIMARY KEY (characterId, skillId),
        check(checkSkillLevel(characterId, skillId, level))
);
```

Functional Dependencies: characterId, skillId -> level

Sample Data:



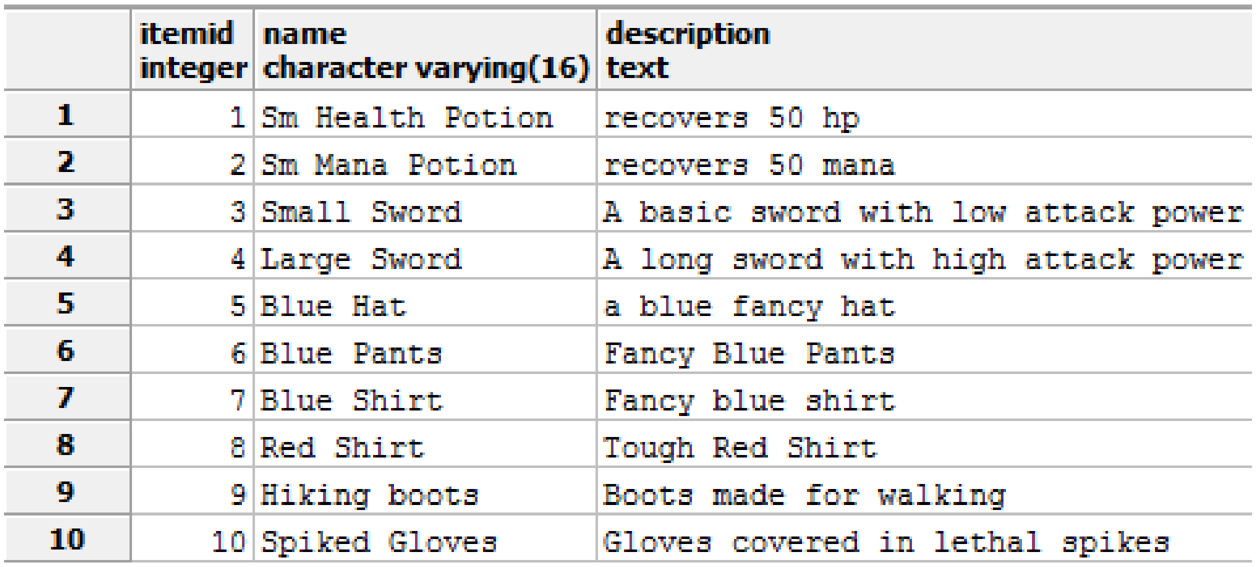
	characterid integer	skillid integer	level integer
1	2	10	0
2	2	1	0
3	2	2	0
4	3	8	0
5	3	7	0
6	2	3	0
7	2	4	0
8	2	9	20

Items Table
Items table lists all items in the game.

```
CREATE TABLE items(
        itemId SERIAL NOT NULL,
        name VARCHAR(16) NOT NULL UNIQUE,
        description TEXT NOT NULL,
        PRIMARY KEY (itemId)
);
```

Functional Dependencies: itemId -> name, description

Sample Data:



	itemid integer	name character varying(16)	description text
1	1	Sm Health Potion	recovers 50 hp
2	2	Sm Mana Potion	recovers 50 mana
3	3	Small Sword	A basic sword with low attack power
4	4	Large Sword	A long sword with high attack power
5	5	Blue Hat	a blue fancy hat
6	6	Blue Pants	Fancy Blue Pants
7	7	Blue Shirt	Fancy blue shirt
8	8	Red Shirt	Tough Red Shirt
9	9	Hiking boots	Boots made for walking
10	10	Spiked Gloves	Gloves covered in lethal spikes

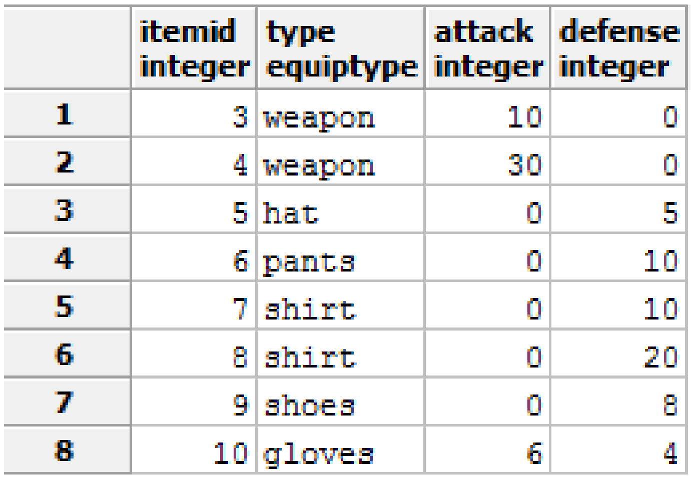
EquipItems Table
The EquipItems Table lists all equip able items in the game.

```
CREATE TYPE EQUIPTYPE as ENUM('hat', 'shirt', 'pants', 'shoes', 'gloves', 'weapon');

CREATE TABLE equipItems(
        itemId INTEGER NOT NULL REFERENCES items(itemId),
        type EQUIPTYPE,
        attack INTEGER NOT NULL DEFAULT 0 check(attack >= 0),
        defense INTEGER NOT NULL DEFAULT 0 check(defense >= 0),
        PRIMARY KEY(itemId)
);
```

Functional Dependencies: itemId -> type, attack, defense

Sample Data:



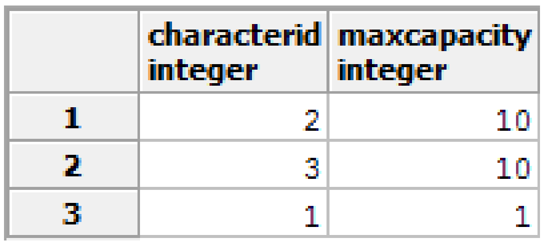
	itemid integer	type equiptype	attack integer	defense integer
1	3	weapon	10	0
2	4	weapon	30	0
3	5	hat	0	5
4	6	pants	0	10
5	7	shirt	0	10
6	8	shirt	0	20
7	9	shoes	0	8
8	10	gloves	6	4

Inventories table
Lists all characters' inventories and capacities.

```
CREATE TABLE inventories(
        characterId INTEGER NOT NULL REFERENCES characters(characterId),
        maxCapacity INTEGER DEFAULT 10,
        PRIMARY KEY (characterId)
);
```

Functional dependencies: characterId -> maxCapacity

Sample Data:



	characterid integer	maxcapacity integer
1	2	10
2	3	10
3	1	1

InventoryContains Table
Lists all the items existing in a character's inventory

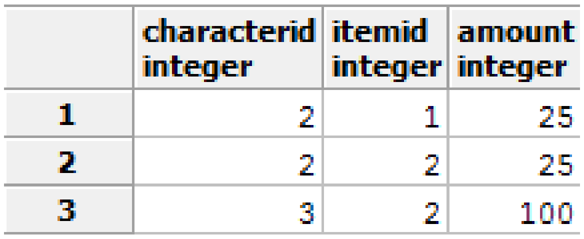
```
CREATE OR REPLACE FUNCTION isBeyondMax(id integer, iid integer) RETURNS boolean
AS $beyond$
DECLARE
        amt integer;
        maxCap integer;
BEGIN
        amt = (SELECT count(characterId) FROM inventoryContains WHERE characterId = id);
        maxCap = (SELECT maxCapacity FROM inventories WHERE characterId = id);
        IF NOT EXISTS (SELECT itemId FROM inventoryContains WHERE characterId = id
AND itemId = iid) THEN
                IF amt >= maxCap THEN
                        RETURN FALSE;
                END IF;
        END IF;
        RETURN TRUE;
END
$beyond$ LANGUAGE plpgsql;

CREATE TABLE inventoryContains(
        characterId INTEGER NOT NULL REFERENCES characters(characterId),
        itemId INTEGER NOT NULL REFERENCES items(itemId),
        amount INTEGER NOT NULL DEFAULT 1,
        PRIMARY KEY (characterId, itemId),

        check(isBeyondMax(characterId, itemId))
);
```

Functional Dependencies: characterId, itemId -> amount

Sample Data:



	characterid integer	itemid integer	amount integer
1	2	1	25
2	2	2	25
3	3	2	100

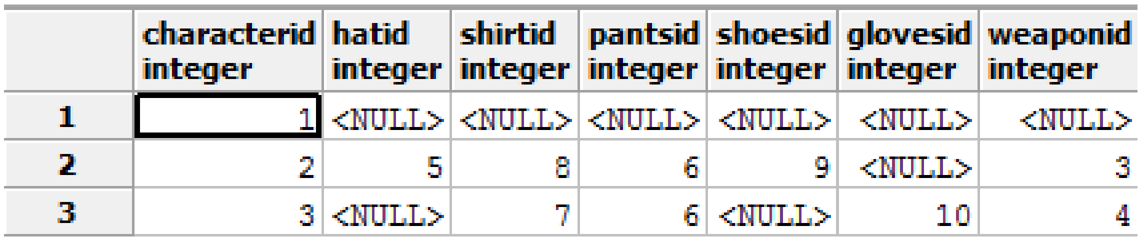
Equipments Table
Lists all the equipped items on characters.

```
CREATE OR REPLACE FUNCTION isProperType(id integer, matchType EQUIPTYPE)
RETURNS boolean AS $properType$
DECLARE
        actualType EQUIPTYPE;
BEGIN
        IF id IS NULL THEN
                RETURN TRUE;
        END IF;
        actualType = (SELECT type FROM equipItems WHERE itemId = id);
        IF actualType = matchType THEN
                RETURN TRUE;
        ELSE
                RETURN FALSE;
        END IF;
        RETURN TRUE;
END
$properType$ LANGUAGE plpgsql;

CREATE TABLE equipments(
        characterId INTEGER NOT NULL REFERENCES characters(characterId),
        hatId INTEGER REFERENCES equipItems(itemId),
        shirtId INTEGER REFERENCES equipItems(itemId),
        pantsId INTEGER REFERENCES equipItems(itemId),
        shoesId INTEGER REFERENCES equipItems(itemId),
        glovesId INTEGER REFERENCES equipItems(itemId),
        weaponId INTEGER REFERENCES equipItems(itemId),
        PRIMARY KEY (characterId),
        check(isProperType(hatId, 'hat')),
        check(isProperType(shirtId, 'shirt')),
        check(isProperType(pantsId, 'pants')),
        check(isProperType(shoesId, 'shoes')),
        check(isProperType(glovesId, 'gloves')),
        check(isProperType(weaponId, 'weapon'))
);
```

Functional Dependencies: characterId -> hatId, shirtId, pantsId, shoesId, glovesId, weaponId

Sample Data:



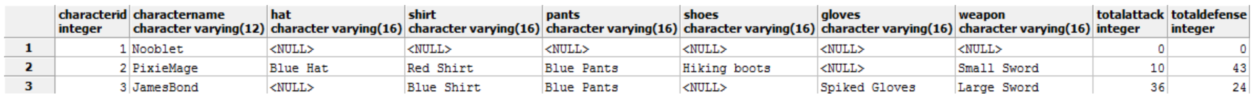
	characterid integer	hatid integer	shirtid integer	pantsid integer	shoesid integer	glovesid integer	weaponid integer
1	1	<NULL>	<NULL>	<NULL>	<NULL>	<NULL>	<NULL>
2	2	5	8	6	9	<NULL>	3
3	3	<NULL>	7	6	<NULL>	10	4

Views

CharacterItemView
Displays all the items a character has equipped and the total attack and defense.

```
CREATE OR REPLACE VIEW characterItemView AS
SELECT c.characterId, characterName, hi.name AS hat, si.name AS shirt, pi.name AS pants,
shi.name AS shoes, gi.name AS gloves, wi.name AS weapon,
        (coalesce(h.attack, 0) + coalesce(w.attack, 0) + coalesce(s.attack, 0) +
coalesce(p.attack,0) + coalesce(sh.attack,0)
                + coalesce(g.attack,0)) AS totalAttack,
        (coalesce(h.defense, 0) + coalesce(w.defense, 0) + coalesce(s.defense, 0) +
coalesce(p.defense,0) + coalesce(sh.defense,0)
                 + coalesce(g.defense,0)) AS totalDefense
FROM characters AS c
        INNER JOIN equipments AS e ON c.characterId = e.characterId
                LEFT JOIN equipItems AS h ON e.hatId = h.itemId
                        LEFT JOIN items AS hi ON h.itemId = hi.itemId
                LEFT JOIN equipItems AS w On e.weaponId = w.itemId
                        LEFT JOIN items AS wi ON w.itemId = wi.itemId
                LEFT JOIN equipItems  AS s ON e.shirtId = s.itemId
                        LEFT JOIN items AS si ON s.itemId = si.itemId
                LEFT JOIN equipItems AS p ON e.pantsId = p.itemId
                        LEFT JOIN items AS pi ON p.itemId = pi.itemId
                LEFT JOIN equipItems AS sh ON e.shoesId = sh.itemId
                        LEFT JOIN items AS shi ON sh.itemId = shi.itemId
                LEFT JOIN equipItems AS g ON e.glovesId = g.itemId
                        LEFT JOIN items AS gi ON g.itemId = gi.itemId;
```

Sample Data:

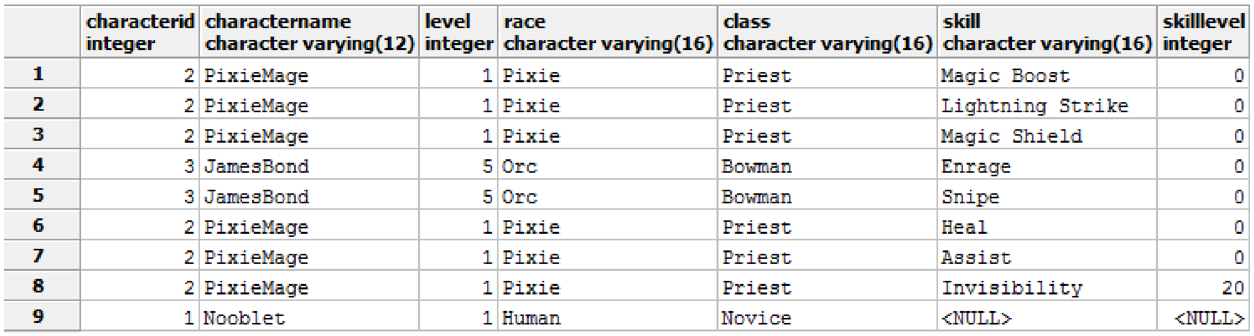


	characterid integer	charactername character varying(12)	hat character varying(16)	shirt character varying(16)	pants character varying(16)	shoes character varying(16)	gloves character varying(16)	weapon character varying(16)	totalattack integer	totaldefense integer
1	1	Nooblet	<NULL>	<NULL>	<NULL>	<NULL>	<NULL>	<NULL>	0	0
2	2	PixieMage	Blue Hat	Red Shirt	Blue Pants	Hiking boots	<NULL>	Small Sword	10	43
3	3	JamesBond	<NULL>	Blue Shirt	Blue Pants	<NULL>	Spiked Gloves	Large Sword	36	24

CharacterSkillView
Displays all the skills a character knows and its level.

```
CREATE OR REPLACE VIEW characterSkillView AS
SELECT c.characterId, c.characterName, c.level, r.name AS race, cl.name AS class, s.name AS
skill, cs.level AS skilllevel
        FROM characters AS c
        LEFT JOIN races AS r ON c.raceId = r.raceId
        LEFT JOIN classes AS cl ON c.classId = cl.classId
        LEFT JOIN characterSkills AS cs ON c.characterId = cs.characterId
        LEFT JOIN skills AS s ON cs.skillId = s.skillId;
```

Sample Data:

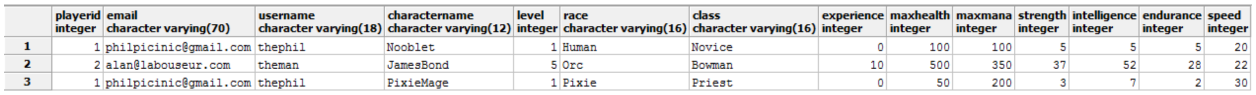


	characterid integer	charactername character varying(12)	level integer	race character varying(16)	class character varying(16)	skill character varying(16)	skilllevel integer
1	2	PixieMage	1	Pixie	Priest	Magic Boost	0
2	2	PixieMage	1	Pixie	Priest	Lightning Strike	0
3	2	PixieMage	1	Pixie	Priest	Magic Shield	0
4	3	JamesBond	5	Orc	Bowman	Enrage	0
5	3	JamesBond	5	Orc	Bowman	Snipe	0
6	2	PixieMage	1	Pixie	Priest	Heal	0
7	2	PixieMage	1	Pixie	Priest	Assist	0
8	2	PixieMage	1	Pixie	Priest	Invisibility	20
9	1	Nooblet	1	Human	Novice	<NULL>	<NULL>

PlayerCharactersView
Displays all the characters belonging to a player's account.

```
CREATE OR REPLACE VIEW playerCharactersView AS
SELECT p.playerId, email, username, characterName, level, r.name AS race, cl.name AS class,
experience,
        maxhealth, maxmana, strength, intelligence, endurance, speed
        FROM players AS p
        LEFT JOIN characters AS c ON p.playerId = c.playerId
        LEFT JOIN classes AS cl ON c.classId = cl.classId
        LEFT JOIN races AS r ON c.raceId = r.raceId;
```

Sample Data:



	playerid integer	email character varying(70)	username character varying(18)	charactername character varying(12)	level integer	race character varying(16)	class character varying(16)	experience integer	maxhealth integer	maxmana integer	strength integer	intelligence integer	endurance integer	speed integer
1	1	philpicinic@gmail.com	thephil	Nooblet	1	Human	Novice	0	100	100	5	5	5	20
2	2	alan@labouseur.com	theman	JamesBond	5	Orc	Bowman	10	500	350	37	52	28	22
3	1	philpicinic@gmail.com	thephil	PixieMage	1	Pixie	Priest	0	50	200	3	7	2	30

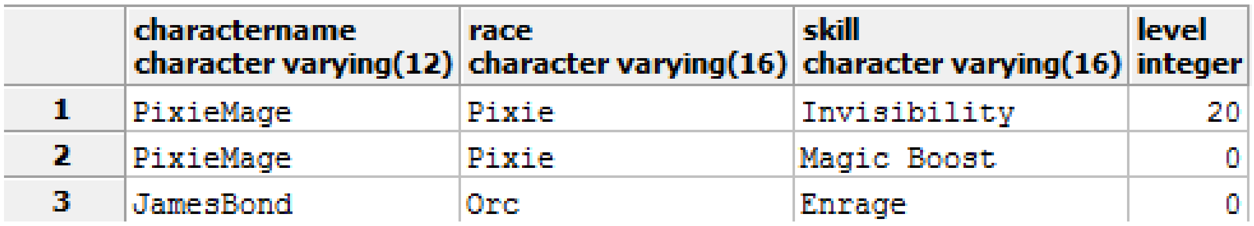
Reports and their Queries

Characters and race skills

Displays all characters with all of their race skills only.

```
SELECT c.characterName, r.name AS race, s.name AS skill, cs.level
FROM characters AS c
INNER JOIN races AS r ON c.raceId = r.raceId
INNER JOIN raceSkills AS rs ON r.raceId = rs.raceId
INNER JOIN skills AS s ON rs.skillId = s.skillId
INNER JOIN characterSkills AS cs ON cs.characterId = c.characterId AND cs.skillId = s.skillId;
```

Sample Data:

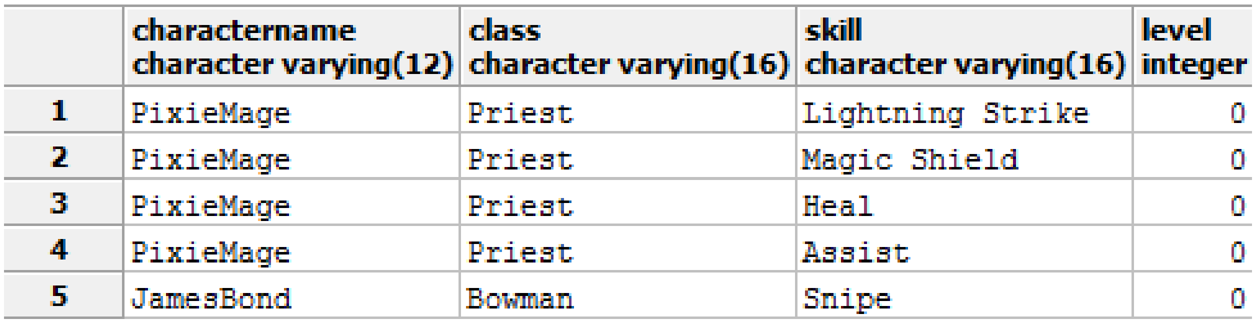


	charactername character varying(12)	race character varying(16)	skill character varying(16)	level integer
1	PixieMage	Pixie	Invisibility	20
2	PixieMage	Pixie	Magic Boost	0
3	JamesBond	Orc	Enrage	0

Characters and class skills

Displays all characters with all of their class skills only.

```
SELECT c.characterName, cl.name AS class, s.name AS skill, cs.level
FROM characters AS c
INNER JOIN classes AS cl ON c.classId = cl.classId
INNER JOIN classSkills AS cls ON cl.classId = cls.classId
INNER JOIN skills AS s ON cls.skillId = s.skillId
INNER JOIN characterSkills AS cs ON cs.characterId = c.characterId AND cs.skillId = s.skillId;
```

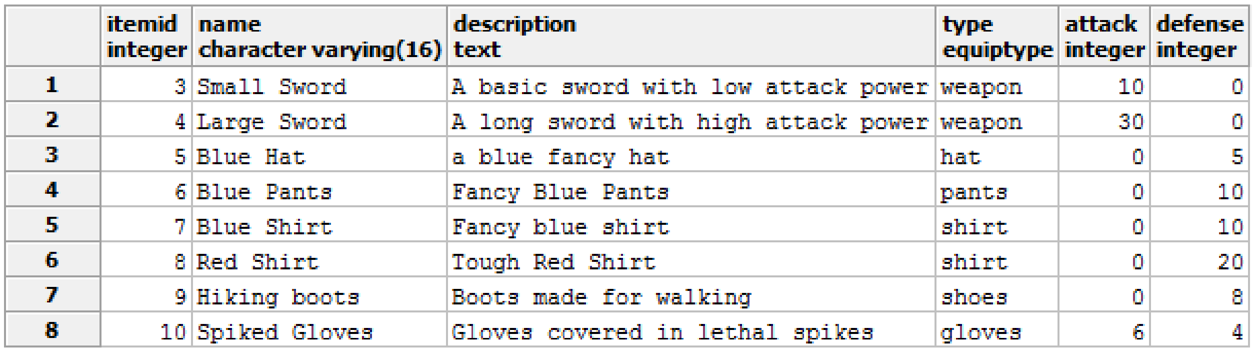


	charactername character varying(12)	class character varying(16)	skill character varying(16)	level integer
1	PixieMage	Priest	Lightning Strike	0
2	PixieMage	Priest	Magic Shield	0
3	PixieMage	Priest	Heal	0
4	PixieMage	Priest	Assist	0
5	JamesBond	Bowman	Snipe	0

Equip able Items

Gives a full display of equip able items.

```
SELECT i.itemid, i.name, i.description, e.type, e.attack, e.defense
FROM equipItems AS e
INNER JOIN items AS i ON e.itemId = i.itemId;
```



	itemid integer	name character varying(16)	description text	type equiptype	attack integer	defense integer
1	3	Small Sword	A basic sword with low attack power	weapon	10	0
2	4	Large Sword	A long sword with high attack power	weapon	30	0
3	5	Blue Hat	a blue fancy hat	hat	0	5
4	6	Blue Pants	Fancy Blue Pants	pants	0	10
5	7	Blue Shirt	Fancy blue shirt	shirt	0	10
6	8	Red Shirt	Tough Red Shirt	shirt	0	20
7	9	Hiking boots	Boots made for walking	shoes	0	8
8	10	Spiked Gloves	Gloves covered in lethal spikes	gloves	6	4

Stored Procedures

addExp()
Adds experience to a character and levels them up if need be. Will also auto generate new levels when the level cap is reached.

```
CREATE OR REPLACE FUNCTION addExp(expAmt integer, id integer) RETURNS void AS
$$
DECLARE
	expNeeded int;
	expHas int;
	nextLevel int;
	maxLevel int;
	nextExp int;
BEGIN
	expNeeded = (SELECT totalExpNeeded FROM levels WHERE level = (SELECT level
FROM characters WHERE characterId = id));
	expHas = (SELECT experience FROM characters WHERE characterId = id);
	IF expHas + expAmt >= expNeeded THEN
		nextLevel = (SELECT level FROM characters WHERE characterId = id) + 1;
		UPDATE characters SET level = nextLevel WHERE characterId = id;
		UPDATE characters SET experience = 0 WHERE characterId = id;
		maxLevel = (SELECT level FROM levels ORDER BY level DESC LIMIT 1);
		IF nextLevel = maxLevel THEN
			nextExp = (((SELECT totalExpNeeded FROM levels WHERE level =
maxLevel) * 3) / 2);
			INSERT INTO levels (totalExpNeeded) VALUES (nextExp);
		END IF;
		PERFORM addExp( ((expHas + expAmt) - expNeeded), id);
	ELSE
		UPDATE characters SET experience = (expHas + expAmt) WHERE characterId
= id;
	END IF;
END;
$$ LANGUAGE plpgsql;
```

affectHealth()
Increases or decreases a character's health but will not go above maxHealth or below 0.

```
CREATE OR REPLACE FUNCTION affectHealth(hpAmt integer, id integer) RETURNS void
AS $$
DECLARE
	maxHp int;
	currHealth int;
BEGIN
	maxHp = (SELECT maxHealth FROM characters WHERE characterId = id);
	currHealth = (SELECT health FROM characters WHERE characterId = id);
	IF currHealth + hpAmt > maxHp THEN
		UPDATE characters SET health = maxHp WHERE characterId = id;
	ELSIF currHealth + hpAmt <= 0 THEN
		UPDATE characters SET health = 0 WHERE characterId = id;
	ELSE
		UPDATE characters SET health = (currHealth + hpAmt) WHERE characterId =
id;
	END IF;
END;
$$ LANGUAGE plpgsql;
```

affectMana()
Increases or decreases a character's mana, but will not go above maxMana or below 0.

```
CREATE OR REPLACE FUNCTION affectMana(manaAmt integer, id integer) RETURNS
void AS $$
DECLARE
	maxMn int;
	currMana int;
BEGIN
	maxMn = (SELECT maxMana FROM characters WHERE characterId = id);
	currMana = (SELECT mana FROM characters WHERE characterId = id);
	IF currMana + manaAmt > maxMn THEN
		UPDATE characters SET mana = maxMn WHERE characterId = id;
	ELSIF currMana + manaAmt <= 0 THEN
		UPDATE characters SET mana = 0 WHERE characterId = id;
	ELSE
		UPDATE characters SET mana = (currMana + manaAmt) WHERE characterId =
id;
	END IF;
END;
$$ LANGUAGE plpgsql;
```

Triggers

There are three triggers for filling in data when a character is created or its class or race is changed. The results can be seen by the sample data from the tables characterSkills, equipments, inventories, some or all of which may have been filled in by a trigger.

```
CREATE OR REPLACE FUNCTION characterFill() RETURNS trigger AS $characterFill$
        DECLARE
                r integer;
                c integer;
        BEGIN
                FOR r IN SELECT skillId FROM raceSkills WHERE raceId = NEW.raceId
                LOOP
                        INSERT INTO characterSkills (characterId, skillId) VALUES
(NEW.characterId, r);
                END LOOP;
                FOR c IN SELECT skillId FROM classSkills WHERE classId = NEW.classId
                LOOP
                        INSERT INTO characterSkills (characterId, skillId) VALUES
(NEW.characterId, c);
                END LOOP;
                INSERT INTO inventories (characterId) VALUES (NEW.characterId);
                INSERT INTO equipments (characterId) VALUES (NEW.characterId);
                RETURN NULL;
        END;
$characterFill$ LANGUAGE plpgsql;

CREATE OR REPLACE FUNCTION skillFill() RETURNS trigger AS $sFill$
        DECLARE
                r integer;
                c integer;
        BEGIN
                FOR r IN SELECT skillId FROM raceSkills WHERE raceId = NEW.raceId AND
skillId NOT IN (SELECT skillId FROM characterSkills WHERE characterId =
NEW.characterId)
                LOOP
                        INSERT INTO characterSkills (characterId, skillId) VALUES
(NEW.characterId, r);
                END LOOP;
                FOR c IN SELECT skillId FROM classSkills WHERE classId = NEW.classId
AND skillId NOT IN (SELECT skillId FROM characterSkills WHERE characterId =
NEW.characterId)
                LOOP
                        INSERT INTO characterSkills (characterId, skillId) VALUES
(NEW.characterId, c);
                END LOOP;
                RETURN NULL;
        END;
$sFill$ LANGUAGE plpgsql;

CREATE TRIGGER characterFill
AFTER INSERT ON characters FOR ROW EXECUTE PROCEDURE characterFill();

CREATE TRIGGER classSkillUpdate
AFTER UPDATE OF classId ON characters FOR ROW EXECUTE PROCEDURE skillFill();

CREATE TRIGGER raceSkillUpdate
AFTER UPDATE OF raceId ON characters FOR ROW EXECUTE PROCEDURE skillFill();
```

Security

This database design currently has two users. The first is "application" which is for the server accessing it with full access. The second is "sysadmin" for viewing player accounts.

```
-- users
CREATE USER sysadmin WITH PASSWORD 'alpaca';
CREATE USER application WITH PASSWORD 'alpaca';

-- permissions (grant / revoke)

REVOKE ALL PRIVILEGES ON characters FROM sysadmin;
REVOKE ALL PRIVILEGES ON classes FROM sysadmin;
REVOKE ALL PRIVILEGES ON races FROM sysadmin;
REVOKE ALL PRIVILEGES ON characterSkills FROM sysadmin;
REVOKE ALL PRIVILEGES ON skills FROM sysadmin;
REVOKE ALL PRIVILEGES ON classSkills FROM sysadmin;
REVOKE ALL PRIVILEGES ON raceSkills FROM sysadmin;
REVOKE ALL PRIVILEGES ON equipments FROM sysadmin;
REVOKE ALL PRIVILEGES ON inventories FROM sysadmin;
REVOKE ALL PRIVILEGES ON levels FROM sysadmin;
REVOKE ALL PRIVILEGES ON inventoryContains FROM sysadmin;
REVOKE ALL PRIVILEGES ON items FROM sysadmin;
REVOKE ALL PRIVILEGES ON equipItems FROM sysadmin;
```

Implementation Notes / Known Problems / Future Enhancements

The implementation went very well. One of the difficulties was how to do certain things without blowing the scale out of proportion. For example equip able items could be completely separate for items and then they can separate inventories or complicatedly combined inventories. For simplicity sake I chose to just have equip able items subtype items. There is a similar compromise with classes where in a class can branch off to a higher more powerful class, such as Mage to Priest or Archmage. I left in class levels such that Priest at level 2 is higher than mage at level 1, but the correlation that a Mage can become a Priest is not there. For a future enhancement, this could probably be done with an associative table that maps one classId, to a classId it can become and possibly at the character level that change can happen.

The biggest challenge were some of the more complex check constraint that call user functions. The problem here is there are queries that are made, but since the data is checked before being inserted some of the data is missing. To fix this with the skill level constraint I passed in the new skill level into the function as well. However for the inventory capacity check, the problem is more complicated as I can’t pass in a count. Rather what I did was pass in both the characterId and itemId and checked for it in the associative table. If the entry didn’t exist, that would mean it must either be a new item being inserted or a previous item being updated to a new one. At this point regardless of action, it checks if the inventory is already full and fails the constraint if it is. It works if you insert a new item and inventory is already full. However it creates a side effect where if the inventory is full and you update one item to another item it fails even though you aren’t going past capacity. This is completely bad because this should happen anyway as a Red Potion doesn’t magically become a Large Sword. If anything the two items might be traded, but then the red potion should be removed before the large sword added.

One thing that I did not like and might consider a problem was the use of serial, an auto incrementing integer as primary keys. It made inserting test data difficult as if there were errors the sequence would be out of order and dropping and recreating tables caused issues reinserting data. Because of this I had to be very careful when recreating the whole schema and test data. It would also be a huge problem when the database becomes used in clusters and there is data replication among many database servers. After a little research I came along the UUID type, which would be much better used in some cases as a primary key. Other enhancements could be adding or removing needed attributes and just generally growth of the database to cover more features like monsters, maps, guilds, parties, etc.