$$= \frac{-a^2 + a^2 + a - a}{a+1}$$

$$= 0$$

$\Rightarrow$ The inverse element exists for all elements in $(\mathbb{R} \setminus \{-1\}, *)$.

Commutativity

$a * b = ab + a + b$

$b * a = ba + b + a$

$= ab + a + b$

$\Rightarrow a * b \equiv b * a$

$(\mathbb{R} \setminus \{-1\}, *)$ is associative.

Conclusion

$(\mathbb{R} \setminus \{-1\}, *)$ is an Abelian group.

2.1) b)

$3 * x * x = 15$

$\Rightarrow (3x + 3 + x) * x = 15$

$\Rightarrow (4x + 3) * x = 15$

$\Rightarrow (4x^2 + 3x) + (4x + 3) + x = 15$

$\Rightarrow 4x^2 + 8x - 12 = 0$

$\Rightarrow x^2 + 2x - 3 = 0$

$\Rightarrow (x + 3)(x - 1) = 0$

$\Rightarrow x = -3 \quad \text{or} \quad x = 1$